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An Ecological Study of

Goose Island, British Columbia

with Special Reference to Mammals and Birds

by

C. J. GUIGUET

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An Ecological Study of Goose Island, British Columbia, With Special Reference to Mammals and Birds

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INTRODUCTION

The Goose Islands, lying off the British Columbia mainland coast, comprise an outer unit in a complex insular pattern in which geographical barriers of salt water intensify generally to westwards.

Because of its central location, small size, and complete isolation, this group was selected in 1948 as an area for field investigation by the University of British Columbia and the Provincial Museum. Mr. Patrick Martin and myself constituted the field party.

In view of the small area involved it was thought that four months from May through August would enable the party to make representative collections of the avian and mammalian faunas, and to gather specimens of the flora. In addition, equipment was supplied for collecting specimens of marine vertebrates and invertebrates from the surrounding waters. In these respects the field party accomplished what it had set out to do. Some 400 specimens of birds and mammals were collected and prepared, and adequate notes were maintained throughout the period. Over 1000 specimens of marine fishes and invertebrates were also collected for future study and a representative collection of plants was made.

The field work was initiated on May 13 and terminated at the end of August. Over and above the qualitative examination of the fauna, studies were undertaken to obtain some quantitative information upon the ecological distribution of the mammals and birds. To accomplish this, emphasis was placed upon the small mammal

work in May and June in order to have the raw data collected before young animals of the year began to run. This enabled us to operate only four quadrats in each habitat occupied by small mammals, but had the advantage of dealing only with adult animals, except in the case of shrews (Sorex obscurus), in which species the young were already out. Preliminary investigations revealed an equal amount of sign in the two types of coniferous forest occurring. For the purposes of small mammal study, these types are included under one heading in the mammal quadrat work, and separately under floral analyses.

This paper is a presentation of the results obtained in the mammalian and avian studies only; it includes the distribution of habitat types regardless of utilization by birds or mammals. The major problem entails the floral analyses of the vegetated habitats occupied by small mammals and birds, determination of relative abundance of these animals in each habitat and, where possible, the determination of factors responsible for the observed distributions. While investigations, similar in part to that presented here, have been carried out on the mainland in the eastern part of the Continent (Townsend, 1935), to my knowledge no comparable studies have been conducted on the Pacific coast. It is hoped that this paper will act as a forerunner to more comprehensive and intensified studies on our coastal islands.

In acknowledgment I wish to thank Dr. I. McTaggart Cowan, under whose direction this research was conducted; Dr. W. A. Clemens, head of the Department of Zoology, and Dr. G. C. Carl, Director of the Provincial Museum, for valuable suggestions and co-operation; Mr. George A. Hardy, Provincial Museum Botanist, and Dr. T.M.C. Taylor, Department of Biology and Botany, for identifications and suggestions pertaining to the flora; and Dr. P.A. Larkin for hours spent in statistical analyses and critical examination of the data. In addition, I wish to thank the secretarial staff of the Provincial Museum for technical assistance in preparation of the manuscript.

I am especially grateful to Mr. P. W. Martin whose intimate and practical knowledge of the British Columbia coast and its fauna, whose skill at navigation and seamanship, and whose affable good fellowship, combined to make the Goose Island expedition both profitable and pleasant.

Sections of the following paper submitted in partial requirement for the degree of Master of Arts at the University of British Columbia, are presented here by kind permission of Dr. W. A. Clemens, head of the Department of Zoology at that institution.

GEOLOGICAL BACKGROUND

As far as I have been able to determine, no geological publications dealing specifically with the Goose Island group have been printed. McCabe and Cowan (1945) reviewed the geological background of the area in question, and of British Columbia in general, in a paper dealing with small mammals and the problem of insularity. From this review of the literature I quote here--"Though it is not difficult, whether on the ground or from the results of research, to demonstrate the recent ice-coverage of almost any fraction of the British Columbia region, the most insidious criticism of the hypothesis in its biological implications remains unanswered. This is the allegation that, while the phenomenon in its broad sense is proved, the local estimates of elapsed time cannot be so perfect as to prove synchrony of the latest glaciation, --to prove, that is, that at any given moment throughout the region, coverage was so uniform as to displace, everywhere and at once, the vast majority of present forms of mobile vertebrate life." These workers go on to say, however, that the coastal range strip, with which we are mainly concerned, does show evidence of glacial uniformity and synchrony, and that the evidence of recent climatic change is overwhelming. "The timbered zones show fresh and universal evidence of recent coverage. The chance that such degrees of change within the limited area could have been intermittent or localized is almost nil."

The Goose Island group then, in all probability, has become occupied by the vegetation it carries and the animal influents it harbours, during that period of time which has elapsed since the retreat of the last or Vashon ice sheet. That these animals invaded directly or indirectly from the adjacent mainland seems logical from a geographic point of view, and appears biologically sound in view of their close affinities to the mainland forms.

LOCATION AND GENERAL DESCRIPTION

The Goose Island group is located some $23\frac{1}{2}$ miles off the British Columbia mainland coast, with a latitude and longitude of 51:58:00 degrees north, 128:27:00 degrees west at their approximate centre. They are the outermost islands at this latitude (Fig. 1) bounded on the west by the open Pacific. To the east lies an arm of the sea eight miles in width, known as Queen's Sound. This separates Goose Island from the nearest substantial land mass, Hunter Island. Deep channels approximately one mile in width, separate the group at the north and south ends from the Broken Islands and the Gosling Rocks respectively, which are in turn, completely isolated. The group consists of six main islands. Goose Island, upon which most of the investigations were conducted, covers 4521.50 acres. The areas of the others are as follows: Gosling Island, 773 acres; Duck Island, 263 acres; Swan Island, 168 acres; Gull Island, 16.40 acres; and Snipe Island, 6.39 acres. There is, in addition, considerable acreage of rocky seashore, sandy, and boulder beaches, which are exposed in varying degrees with falling tides. These expanses connect all islands of the main group at low tide with the exception of Duck Island, which remains separated by a narrow channel, but which may dry briefly during the periods of extremely low tides.

Over one hundred small reefs and islets are located in close proximity to the shores of the main group. The majority of these are little more than sea-washed rocks, but some of the larger islets are vegetated. The group is approximately $6\frac{1}{2}$ miles long, measured from north to south, by $2\frac{1}{2}$ miles wide, measured from east to west. The largest island of the group is indented on the southwest side by a tidal mud and sand flat, referred to in this work as the lagoon. The lagoon varies in width from a few yards to half a mile, and extends approximately one mile in a northerly direction. The flat is bounded on the west by low, rocky seashore and a narrow fringe of grass. On the northern and eastern sides lie flat, grassy meadows which vary considerably in extent. The Goose Islands are, for the main part, bounded on the outer peripheries by rocky seashore. Only a few sandy sea beaches interrupt this continuity of rock.

Viewed from a distance the islands appear heavily wooded, but closer investigation reveals that the main island (Goose), and part of Gosling Island are comprised of muskeg, surrounded by a

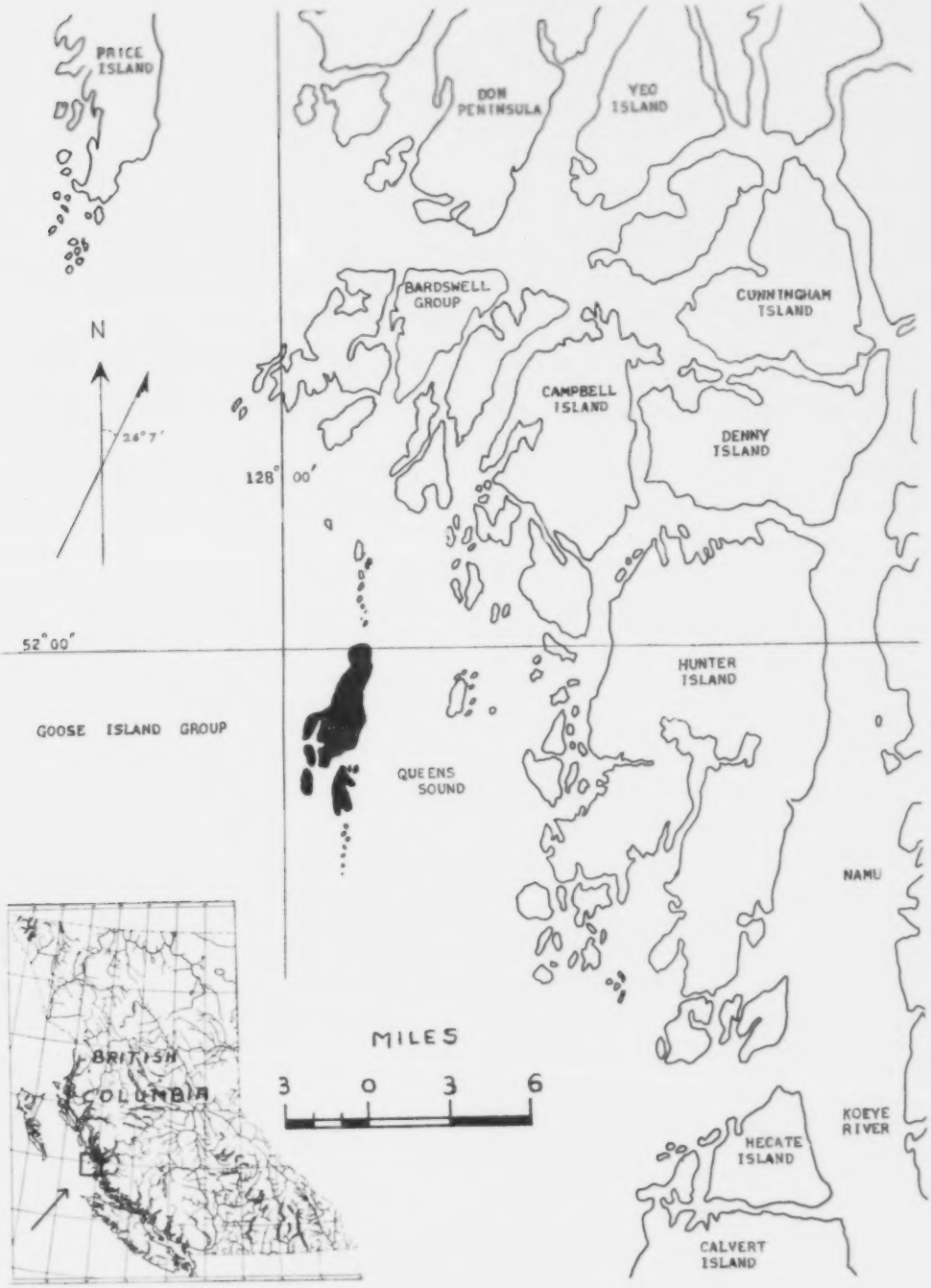

Fig. 1. Map showing relative position of the Goose Island Group.

fringe of coniferous forest varying in width from 25 to 300 yards. At some points on the east coast the muskeg extends through the forest to the rocky seashore. The four remaining islands are timbered throughout. The extent and floral constituents of the various habitats are discussed fully in the text.

Thus the Goose Island group supports well-defined floral associations and habitat types, characteristic of the outer fringe of islands at this latitude. It is, at the same time, a well isolated, ecological unit surrounded by deep expanses of salt water, which are subject to strong and treacherous tidal currents. Some of the smaller islets mentioned are well isolated in themselves.

CLIMATE

"It must be remembered that we have no data whatsoever for the true outermost shorelines, and that the excellent climate of that narrow strip is officially unknown." This statement by McCabe and Cowan (1945) still holds true. No records of climate are yet available for the Goose Island group and other outer fringe islands.

The climate was indeed excellent on the group in the summer of 1948. The small mammal work was carried out during a period of unvarying sunshine, the days repeating themselves identically in the climatic sense, thus eliminating a potential source of error that is all too prevalent, often unavoidable, and not often mentioned in works of this kind. The mainland coast and inner islands during that summer suffered almost continual rain and cold. Prevailing winds carried widely dispersed cumulus clouds from the sea, over the outer fringe and to the mountains, where they shed their moisture on the coast and closely adjacent islands. During the occasions when precipitation did occur on the Goose Islands, the phenomenon of rain approaching across Queen's Sound against the wind, presented an unusual sight.

Whether the conditions that prevailed were atypical is difficult to say in the light of inadequate knowledge. If they were atypical, the effect, if any, upon the mammalian populations, can be determined only by future studies after several years of observations have established annual mean precipitations, relative humidities, and temperatures.

For the purpose of this research, however, the daily climatic constancy which existed at the time of operations was fortunate and constituted an exceedingly pleasant change from previous summers spent in the northern coastal areas.

FLORAL ANALYSES AND DESCRIPTION OF HABITAT TYPES

An initial inspection revealed the existence of eleven well-defined vertebrate habitats on and about the islands, some of which may be regarded as distinct floral associations. These habitats are coniferous forest, meadow, muskeg, rocky seashore, sandy sea beach, tidal mud flats, beach debris, coast littoral, and pelagic waters.

Systematic floral analyses were carried out in the forest, meadow, and muskeg habitats. The coniferous forest was subdivided into two sections for botanical study because of its diverse appearance. The remaining habitats, which were sparsely vegetated were not treated systematically.

Rough approximations of habitat size and occurrence were recorded, in view of future refinement, from aerial photographs, which had supposedly been taken during the recent war. Unfortunately, the areas illustrated in Fig. 2 are diagrammatic representations indicating relative dispersion and position only.

Coniferous Forest

Two types of plant associations are included in the general heading of coniferous forest. One, the typical coast climax association of cedar, hemlock, and spruce, the other, in which cedar and hemlock are in association with jackpine, yellow cedar, and yew. (Figs. 3 and 4). This stunted forest appears to form an ecotone between the spruce, hemlock, and muskeg association and also predominates in rocky areas on the east coast of the island.

In view of the small area involved it seems unlikely that the cause or causes leading to this differentiation can be attributed directly to climate. It would seem rather, that they are due to prevailing ecologic factors, coupled with normal plant succession towards a spruce-hemlock climax. A general gradient from the

Fig. 2. Distribution of floral associations on the Goose Islands.

Fig. 3. Cedar-hemlock and spruce association on the Goose Islands.

Fig. 4. Stunted ecotone-type of forest on the Goose Islands.

sea is apparent throughout most of the wooded areas, although the cedar-hemlock stands at the north and south ends of Goose Island are on relatively flat ground. Except for a possible retaining effect by the contours of underlying rock formations, drainage seems reasonably adequate on the coastal slopes. The possibility of fire as an agent responsible for the diversification of coniferous types has been considered. Some ancient fire scars were observed in both types of forest, but in view of the length of time which has elapsed since fire swept the islands and with almost identical floral distributions existing on other outer fringe groups, it seems more probable that the postulated soil factors, drainage, and associated plant succession are the important causative agents here.

The general distribution of the cedar, hemlock, and associated spruce on these islands seems to substantiate McCabe and Cowan (1945) in their observations that the development of spruce is not reduced by outside exposure to the sea. In fact the distribution here seems to indicate the opposite. It has been pointed out (Dr. T.M.C. Taylor, Pers. Comm.) that a lack of seedling trees, coupled with the heavy occurrence of sphagnum throughout the cedar-hemlock association on Goose Island may indicate a post-climax condition. In accounting for the lack of seedlings in the narrow coniferous belt , another possibility is the almost complete utilization of available spruce cones by Peromyscus. This, however, does not account for the hemlock and red cedar which may not be utilized. The problem of plant succession cannot be discussed fully here. Whether the seral stages represented here are progressing towards a cedar-hemlock climax or retrogressing to another type, remains undetermined. The outer islands present a fascinating source of a study to the plant ecologist; that they have not been worked more thoroughly is surprising. The boundaries between the two types of forest are characterized by the gradual blending of indicative species over a short linear space, giving, from the distance, an appearance of abrupt change.

The floral composition of the coniferous forest was assessed by the Aldous method (1944). Strips 300 yards in length were chosen at random. Plots of one one-hundredth acre were spaced at 50-yard intervals on these strips, and the coverage by plant species recorded on a mean basis as described in the foregoing reference. Twenty-four plots were run in each coniferous type.

Table I--Percentage Occurrence and Cover by Plant Species in Cedar-Hemlock Forest on Goose Island, British Columbia, July 1948.

Plant Species	Occurrence	Cover
Sphagnum sp.	100	56.8
Peltigera canina	83.3	9.8
Maianthemum bifolium	75.0	18.2
Tsuga heterophylla	70.8	33.7
Menziesia ferruginea	66.8	7.5
Vaccinium	62.5	6.8
Gaultheria shallon	58.3	22.7
Thuja plicata	50.0	17.7
Rubus spectabilis	50.0	7.2
Polypodium hesperium	45.8	2.2
Struthiopteris spicant	45.8	4.3
Picea sitchensis	37.5	16.4
Prenanthes hastata	29.1	0.2
Streptopus amplexifolius	28.1	0.2
Tiarella trifoliata	25.0	1.2
Usnea sp.	16.6	8.3
Galium trifidum	12.5	0.6
Coptis asplenifolia	12.5	2.7
Lonicera involucrata	12.5	0.4
Vaccinium caespitosum	12.5	0.6
Echinopanax horridum	12.5	1.6
Calamogrostis inexpansa	12.5	4.3
Aspidium spinulosum	8.3	0.4
Lysichiton americanum	4.1	0.2
Stereocaulon sp.	4.1	0.2
Malus rivularis	4.1	2.9
Rubus pedatus	4.1	1.2
Alnus sitchensis	4.1	0.2
Pteris aquilina	4.1	0.2
Conioselinum gmelini	4.1	0.2
Vicia gigantea	4.1	0.2
Moneses uniflora	4.1	0.2

Table II--Percentage Occurrence and Cover by Plant Species in Ecotone-Type Forest on Goose Island, British Columbia, July 1948.

Plant Species	Occurrence	Cover
Gaultheria shallon	100	38.1
Sphagnum sp.	100	55.2
Thuja plicata	91.7	40.2
Tsuga heterophylla	83.3	16.9
Maianthemum bifolium	79.2	4.0
Struthiopteris spicant	75.0	7.9
Coptis asplenifolia	75.0	4.3
Menziesia ferruginea	66.7	5.4
Vaccinium ovalifolium	62.5	3.1
Carex sitchensis	58.3	6.0
Chamaecyparis nootkatensis	45.8	15.2
Calamogrostis inexpansa	41.7	2.1
Pinus contorta	37.5	14.8
Ledum groenlandicum	37.5	4.0
Linnaea borealis	33.3	1.7
Caltha biflora	33.3	4.4
Lysichitum americanum	33.3	1.7
Picea sitchensis	20.8	11.9
Taxus brevifolia	16.7	4.0
Empetrum nigrum	16.7	1.9
Rubus spectabilis	16.7	0.8
Pteris aquilina	16.7	1.9
Coptis asplenifolia	16.7	1.9
Polypodium hesperium	12.5	0.6
Streptopus amplexifolius	12.5	1.7
Stereocaulon sp.	8.3	0.4
Cladonia sp.	8.3	1.5
Usnea sp.	8.3	0.4
Lycopodium selago	8.3	0.4
Malus rivularis	4.2	0.2
Sanguisorba sitchensis	4.2	0.2
Drosera rotundifolia	4.2	0.2
Peltigera canina	2.1	1.0

The coverage by species and the occurrence within each plot are recorded in percentage. (Tables I and II).

The methods of appraisal here are not intended as a refined treatment of floral composition but as a gross analysis indicating the relation of the plant species involved regarded from a cover point of view rather than by number of individual plants occurring.

The Muskeg Habitat

Comparatively small areas of muskeg are located on Gosling Island but the study of this habitat was confined to Goose Island proper. Here the main part of the interior is comprised of this type. (Figs. 2 and 5). The island resembles a shallow saucer or catch basin with rising timbered coastal slopes levelling off and depressing generally towards the centre forming a shallow rim around the island. The topography of the interior is marked by numerous rocky outcroppings, ridges, and low hills of varying size forming a series of secondary catch basins. The low lying ground is characterized by pot holes and a general coverage of sphagnum, moss, and lichens. From this understory other plants have established themselves. Stunted jackpine, many of them dead, are dispersed over the area. The higher ground, hills, and ridges are wooded with the ecotone-type forest.

The presence of this muskeg is probably due to hydrophytic conditions resulting from the damming effect of the catch basins, in other words, inadequate drainage. This is borne out by the fact that in periods of heavy precipitation the pot holes become filled with water, the muskeg becomes generally very wet and the several small streams draining the interior come in spate carrying the great excesses over the coastal rim to the sea. The streams in a short while are almost dry again, mere trickles which are almost stationary. The pot holes however retain the water for a much greater length of time, depending upon the intensity and humidity of the prevailing westerlies.

A line-intercept method was used in assessing the floral composition of the muskeg. Here again the raw data were collected from a cover point of view only. Two stout upright wires were used to spread a taut horizontal line 100 inches long. Each 100 inches was regarded as a plot, one inch representing one per cent. Total cover of the species occurring was measured in inches along the line regardless of overlap. For example, in a

given plot 100 per cent cover of sphagnum moss could be recorded along with 100 per cent of some higher growing species that chanced to intercept the total length of the line. If still higher growing species occurred, the three cover levels could, theoretically, show a percentage of 300 for the plot.

Twenty-four plots spaced at 100-yard intervals were selected at random running transversely across the muskeg from forest edge to forest edge.

Table III lists the species occurring in terms of percentage of cover and occurrence in plots.

The Meadow Habitat

The meadow habitat on the Goose Islands is limited to a few acres bordering the shores of the lagoon and to three small areas on the south western isle. (Figs. 2 and 6). The meadows on the main island, where the floral assessment was done, are continuous but vary in width from a few feet to between 50 and 100 yards. Narrow necks of meadow penetrate into the coniferous forest at several points, chiefly where rills draining the interior occur.

Numerous fresh and brackish-water pot holes located in the area represent a striking series of transitional stages in soil formation. Those nearer the shores contain a permanent supply of fresh water and harbour hydrophytic plants. Others, devoid of plant life, lose their water in dry spells exposing mud bottoms, often two or three feet below the general level of the meadows; some of these become caked after long exposure, while others become partially or wholly filled by accumulating debris from the annually dying vegetation. These areas become vegetated by the plant life of the meadow. Salicornia is dominant on those immediately bordering the sea which are washed periodically by salt water. Others have become vegetated completely by Plantago maritima leaving only patterns of irregular darker green patches to mark what had once been a pot hole. On some of these, the "harder" grasses of the meadow are encroaching.

The gradual transitional stages from pot hole to meadow represented here may well bear further investigation by a competent agronomist or plant ecologist.

Table III--Percentage Occurrence and Cover by Plant Species in Muskeg on Goose Island, British Columbia, July 1948.

Plant Species	Occurrence	Cover
Cladonia sp.	95.8	63.8
Sphagnum sp.	91.6	67.0
Myrica gale	91.6	12.7
Juniperus communis	72.5	17.2
Ledum groenlandicum	58.3	3.1
Sanguisorba sitchensis	58.3	4.9
Empetrum nigrum	50.0	5.5
Carex limosa	50.0	1.7
Scirpus caespitosus	41.7	4.4
Chamaecyparis nootkatensis	37.5	5.3
Pinus contorta	33.3	4.7
Lycopodium selago	29.2	2.4
Tofieldia intermedia	25.0	0.7
Drosera rotundifolia	25.0	0.5
Eriophorum chamissonis	25.0	0.5
Carex stylosa	20.8	0.6
Caltha biflora	16.7	1.5
Kalmia polifolia	12.5	0.2
Rynchospora alba	12.5	0.8
Gaultheria shallon	8.3	0.2
Coptis asplenifolia	8.3	0.6
Linnaea borealis	0.3	0.1
Rubus pedatus	8.3	0.2
Thuja plicata	4.2	0.04
Alnus sitchensis	4.2	1.1
Struthiopteris spicant	4.2	0 5
Habenaria leucostachys	4.2	0.04
Coptis asplenifolia	4.2	0.04
Gentiana propinqua	4.2	0.1
Pinquicula vulgaris	4.2	0.1
Carex sitchensis	4.2	0.04
Plantago macrocarpa	4.2	0.04
Calamogrostis inexpansa	4.2	0.04
Deschampsia caespitosa	4.2	0.04
Stereocaulon sp.	4.2	0.2
Bare Rock	4.2	0.8

Fig. 5. Muskeg on the interior of Goose Island.

Fig. 6. Meadow habitat on the Goose Islands.

A point sample method of range assessment (Clarke, 1942) was used in this habitat. The point sample unit improvised in the field, of wire and cardboard, carried 18 points. Each unit was considered a plot and 56 such plots were selected at random over the meadow for a total of 1000 points, 10 points only being included in the last plot. Seventy-one per cent of the 1000 points struck bare ground. The percentage composition is calculated on the remaining 29 per cent in which the points actually struck the root of a plant. In cases where beds of sphagnum or cladonia occurred, all points striking the mass were included. Simultaneous strikes were recorded where certain species of grass were growing up through the moss accounting for a total percentage greater than 100.

The results here are not viewed from the cover standpoint, but as an indication of the floral composition of the meadow from relative numbers of different plant species occurring, as illustrated in Table IV.

The Beach Debris Habitat

On many stretches of the British Columbia coast, where the tidal drifts permit, a welter of debris composed mainly of the logs, roots, and stumps of dead coniferous trees is found piled up on the sea beaches. The units making up these jams become lodged. Additional debris accumulating through the years often extends the mass from the high-water line to the forest edge, and sometimes into the forest proper for short distances. In many cases the logs are piled to a height of fifteen to twenty feet, depending upon the ferocity of the gale and the state of the tide upon which they were borne. Interlocking units, shifting sands, and encroaching plants of the forest edge and high beach combine with other agents such as rock and mud in anchoring the accumulating mass until it often becomes a permanently fixed and integral part of the shoreline. These coastal log jams form a distinct habitat type utilized by certain species of birds and small mammals.

The beach debris habitat on the Goose Island group occurs on all sides of the islands where conditions are favourable. (Figs. 5, 7, and 9.) It seldom exceeds a width of 25 yards, and the debris in most cases is composed of from one to three layers varying in depth to four feet.

Along the forest edge of this habitat, Gaultheria, Alnus, and Rubus, have encroached to a considerable extent, where the

Table IV--Percentage Composition of Meadow by Plant Species on Goose Island, British Columbia, July 1948.

Plant Species	Composition
Sphagnum sp.	30.0
Cladonia sp.	15.5
Triglochin maritima	13.1
Deschampsia caespitosa	7.9
Salicornia ambigua	6.6
Juncus balticus	6.2
Carex bauxbaumii	5.5
Empetrum nigrum	5.2
Plantago maritima	4.1
Festuca rubra	4.1
Eriophorum chamissonis	3.4
Potentilla anserina	2.8
Plantago macrocarpa	2.4
Hordeum nodosum	2.1
Achillea millefolium	2.1
Ledum groenlandicum	1.7
Glaux maritima	1.7
Carex limosa	1.0
Elymus arenarius	1.0
Castilleja miniata	0.6
Calamogrostis inexpansa	0.6
Gaultheria shallon	0.6
Agrostis exarata	0.3
Sisyrinchium idahoense	0.3
Cochlearia officinalis	0.3
Maianthemum bifolium	0.3
Atriplex patula	0.3

Fig. 7. Beach debris habitat on the Goose Islands.

substratum is composed of sand. Here also the older debris carries thick mats of sphagnum moss below which the decaying wood has furnished bases for small cedars and hemlocks and lesser plant life. Lower down the beaches, in the central line of the habitat, but still above the high-tide mark, irregularly occurring stands of Lathyrus, Atriplex, and Vicia grow up among the debris. The former often spreads back over the logs, intertwining with the woody plants already established to form dense thickets over the logs along the high beach. Beneath these thickets, between and under the logs, are mazes of passages, runways, and chambers admirably suited as dwelling places for mice.

The outer margin of the beach debris, which is washed regularly by the tides, is devoid of plant life.

Where the logs have "hung up" on rocky seashore, plant life is generally much less abundant. In some areas, however, the spaces between the larger units have become filled with smaller debris, and cast up seaweed, forming suitable bases for plants. Newly established jams bear no plant life. Some of these may be temporary and will disappear under the onslaught of winter storms.

The development of permanent beach debris habitat depends upon a multitude of factors: time, nature of the bases, prevalence and intensity of storms, tidal drift, exposure, and so on. It is obvious then, that many types, all differing in certain aspects, are to be found along the coast and shores of the coastal islands in British Columbia; this holds true on the Goose Island group as well.

The Rocky Seashore

As previously indicated the rocky seashore forms a large part of the outer shoreline of the Goose Island group. (Figs. 8 and 9.)

The margin of rock between the sea and the forest is generally narrow and precipitous, seldom exceeding twenty or thirty feet in width.

The vegetation is sparse, Potentilla villosa dominating, with Fragaria chiloensis also present. Here and there an occasional twisted spruce helps break the monotony of lichen-encrusted rock.

Nearer the forest edge, where there is shelter and an accumulation of soil in the crevices, such plants as Tellima grandiflora, Montia sarmentosa, Trientalis sp., Erigeron salsuginosus, Barbarea vulgaris, and Castilleja sp. are found.

The percentage composition of flora on the rocky seashore of the Goose Islands is not presented here.

The floral analyses of the foregoing habitats was conducted in July at the approximate mean of the four months spent upon the islands. In consequence some earlier and later-appearing varieties of plants were gone or had not appeared when the work was being conducted. These of course, do not appear in the plot results. In addition, some of the less abundant plants did not chance to fall within a plot. Time did not permit the continued running of plots until every possible variety was represented, as had been planned, but a fairly representative collection was made in May and June.

I do not maintain that the collection of plants is complete but I do feel that the work here presented has accomplished its intended objective, in that it gives an indication of the type, diversification and, in most cases, the relative abundance of the characteristic flora on the various habitats discussed.

The plant collection from the Goose Islands is housed at the Provincial Museum in Victoria, British Columbia.

The marine flora of the sandy sea beach, boulder beach, coast littoral, and pelagic waters being beyond the scope of this paper, is not presented here.

Boulder Beach

The boulder beach occurring upon the group is located for the main part between the south end of Goose and the north end of Gosling Island. A considerable stretch is located on the west coast of Goose Island, while short stretches lie between Gosling, Snipe, and Gull Islands. (Fig. 9).

Fig. 8. Rocky seashore dominated the outer margins of the Goose Islands.

Sandy Sea Beach and Tidal Mud Flat

Figs. 10, 11, and 12 illustrate the extent of these habitats on the group. All expanses shown are true sandy beaches except portions of the lagoon. Here there is a considerable amount of soft mud occurring along the central depression and generally mixed with the sand on the flats at the head. The area here appears to be in a stage between tidal mud flat and sandy beach with sand predominating.

MAMMALIAN POPULATIONS

Methods of Study

It is generally conceded that up to, and including the present time no satisfactory method of accurately measuring per unit densities of small mammals has been devised. Various workers, Dice, Blair, Bole, Stickle, and many others have devoted much time to the subject. The conflicting nature of the results obtained by these workers in the use of the snap trap and the live trap quadrat have cast serious doubts upon the validity of either method. Many contributions published have accomplished valuable objectives only in pointing out the pitfalls and difficulties encountered in making a census of small mammal populations (Dice, 1938). Stickle (1947), in an experimental comparison of the two methods, arrived at the conclusion that live trapping, mark, and release, yields more accurate figures than does snap trapping. She indicates that the latter method results in population figures three times as great as those obtained by the live-trap procedure. The experiment, in this respect, indicated also the use of live traps appreciably shortened the range of operations of the mice on the quadrat in question. When the live traps were removed from a large quadrat and a smaller central area of that quadrat snap trapped, it was revealed that the previously marked mice had come from distances greater than the calculated range based on the live-trap data. In view of the fact that per unit densities arrived at by the live-trap methods are based upon this calculated range, the results so obtained must be regarded as questionable approximations with a tendency to indicate fewer animals per unit area than actually occur. When large quadrats are used it is probable that errors of exaggeration resulting from snap-trap

procedures are no more extensive in one direction than those resulting from live-trap methods are in another. The utilization of both methods combined, may yield a calculated mean representing more truthful figures than does the sole use of either one.

When smaller quadrats are used, in which the linear ranges of the mice in question are undoubtedly greater than the dimensions of those quadrats, it is obvious that per unit area density estimates based solely on the area covered by traps will result in exaggerated figures. Some correction then, must be made to compensate for that part of the ranges of the mice which chance to lie outside of the plot upon which they were taken. Such was the case in the work conducted on the Goose Islands. In consequence, the unit area density figures presented here are open to question and are presented only as points of interest and comparison to the percentage calculations upon which the relative abundance of small mammals is based in this paper.

Potentially the live-trap method has greater possibilities than has snap trapping. The latter method kills the mice as they are taken and consequently the calculation of individual ranges is impossible. The removal of a number of animals from a given area also gives rise to sources of error.

The major objection to the use of live traps in this type of research is the influence which these traps exert upon the range of individual mice. Several methods of eliminating this effect have been suggested. Basically all of the methods operate on the same principle, that of closing a trap or group of traps on a quadrat or adjacent quadrats thus allowing the mice to wander further afield and into traps they otherwise would not have visited. Most of these methods involve a large number of traps and subsequent "man hours." In addition the ranges arrived at will still remain directly proportional to the spacing of the traps as long as a set pattern is used. For these reasons and others, they are impractical. It is generally acknowledged that seasonal movements and other variable factors affecting mammalian populations necessitate the completion of an investigation within a short space of time.

A live-trap method employing an expanding quadrat and possibly involving relatively fewer traps has been postulated by Cowan (1949, Pers. Comm.). Beginning at a central area of suitable dimension in a given habitat, a number of live traps are set in close

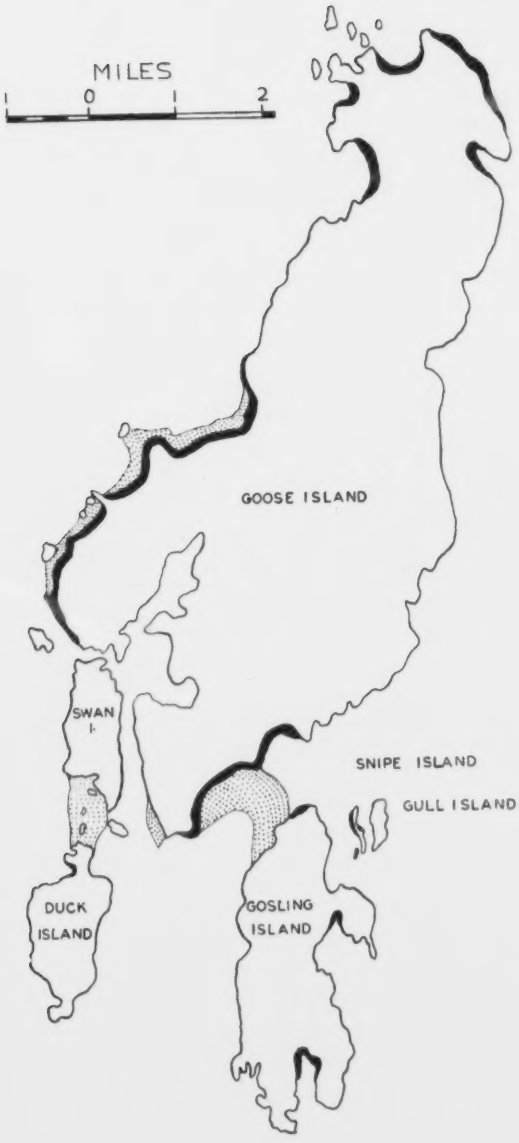

Fig. 9. Location and extent of beach debris (in black); boulder beach (stippled); and rocky seashore (remainder of shore line) on the Goose Islands.

Fig. 10. Location and extent of sandy sea beach (lined) and tidal mud flat (solid black) on the Goose Islands.

Fig. 11. A stretch of sandy sea beach on the Goose Islands showing cast up eel grass.

Fig. 12. A portion of the lagoon showing tidal mud flats.

proximity. The mice taken are marked and released and on succeeding nights the traps are set further and further from the central area. Eventually a point or points should be reached at which the originally marked animals are no longer being taken. Howard (1949) has suggested a similar method in which, stated generally, the traps are lifted from the central area after a sufficient number of animals have been marked and released. A peripheral line of traps is then set around the central area at a distance greater than the expected range of the individuals of the species in question. On succeeding nights this line of traps is moved closer to the central area until marked mice are being retaken.

In dense-cover types where a short cruising range may be expected these methods may well prove effective and yield data from which per unit densities can be calculated with reasonable accuracy. In open-cover type, however, they may necessitate the use of far too many traps. Until they have been subjected to field trials their practicability and accuracy remain unknown.

In the present study snap traps only were available. These I utilized to the best of my ability fully realizing the limitations imposed by variable factors and by the inadequacies of the available equipment.

The three species studied by use of snap-trap quadrat represented the only terrestrial mammals found occupying the Goose Islands (apart from bats). These animals are white-footed mice (Peromyscus maniculatus), long-tailed voles (Microtus longicaudus), and dusky shrews (Sorex obscurus).

Investigations by quadrat were confined to the main island (Fig. 13) and commenced on May 22, terminating on June 7 when the first young Microtus were observed running.

Four quadrats, 70 yards long by 20 yards wide, were run for three consecutive days and nights in each of the four habitats occupied by these mammals. Each quadrat contained 39 traps baited with walnut and set at five-yard intervals in lines of three running transversely. Thirteen such lines constituted the complement for each quadrat. All traps were set in niches deemed most likely to catch mice while still conforming to the five-yard interval. No trap was set within five yards of the outer margin of the quadrat in which it was placed. The margin formed by this five-yard strip,

when considered in per acre calculations, figuratively disperses the animals taken, over an area less, by 400-square-yards, than three times the area actually enclosed by traps. This area is arbitrary and based on an expected exaggeration of roughly three times the per acre density figures that would have resulted had live traps been used. The 400-square-yard difference is regarded as compensatory for the range-shortening effect of the hypothetical live-traps. The standard quadrat used on Goose Island is diagrammatically illustrated on Fig. 14. In calculation of per acre densities the total number of individuals taken in a given habitat in three nights of trapping on four standard plots was considered. For example, Peromyscus taken in all beach debris plots totalled 65 of both sexes. The total area enclosed by four plots 70 x 20 x 4 = 5600 square yards. There are 4840-square-yards in one acre. The calculated density = $\frac{4840}{5600} \times 65 = 56.1$. One acre of beach debris habitat then, is considered to be utilized by an estimated 56 Peromyscus. Similar calculations were used for each species in each habitat.

I want to stress again, at this point, that the density figures so calculated are presented as a basis for comparison and interest only. The discussions are based upon the number of individuals of a species taken in the different habitats presented in percentage and the raw data have been treated by analysis of variance (Snedecor, 1938). Taken at the .01 level of probability it has been indicated that:

1. The observed differences in the total number of individuals of all species cannot be ascribed to chance. In other words the productivity of the various habitat in relation to all species differs due to some product of the habitats.

2. The differences observed in the number of individuals of different species taken in different quadrats cannot be ascribed to chance, but suggest that some species "do better" than others in different quadrats.

3. One species does better in one habitat than it does in another. Consequently, the observed distribution of individuals of different species for specific habitat types is not due to chance, but to intrinsic characteristics of either the species, the habitat, or both.

Fig. 13. Map showing location of small mammal quadrats on Goose Island.

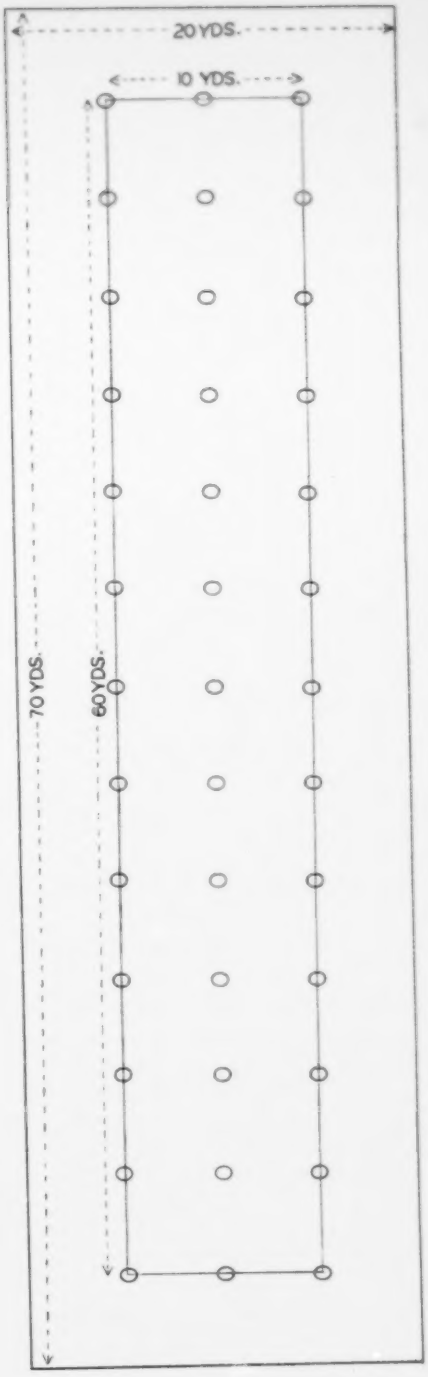

Fig. 14. Diagram of small mammal quadrat used in the Goose Island investigations.

A source of error, of course, still exists in possible differential wandering of individuals of a given species in different habitats. It is assumed from the trapping results obtained that this constitutes for practical purposes, a negligible factor contributing to the relative distributions observed here.

Five small islets were trapped off in an attempt to measure the reliability of the quadrat methods utilized in arriving at per acre densities on the main island.

Islets were selected which bore habitats comparable to those on the main island and which were small enough to be completely covered by the traps available. Unfortunately two of the islets first selected were so trampled by operators setting traps that no valid results were obtained. Another islet, while bearing old sign, yielded no mice or shrews when trapped. The fourtn bore no sign and subsequent trapping proved that it was uninhabited by small mammals. The remaining islet bore no beach debris and harboured no Microtus. In addition, the meadow, muskeg, and coniferous forest present were not laid out in distinct patterns as they were on Goose Island proper. In all a measured 3600 square yards constituted its total area. Fifty per cent of this was in sparse spruce-hemlock forest with a subclimax of Gaultheria. Thirty per cent was in muskeg, represented by a strip along the east shore was vegetated predominantly by sphagnum moss and Ledum. Two small headlands at the north and south were covered by Calamogrostis which also bordered the Ledum stand at the sea, thus representing approximately 20 per cent of the total area as meadow habitat.

The islet was well isolated by approximately 400 yards of sandy sea beach to the west, and by a deep rocky gorge about 30 yards in width on the east. Large expanses of sandy sea beach to the north and deep water to the south completed the isolation. The gorge and sandy sea beach were inundated at all times except during periods of extremely low tide.

An untrapped headland at the southern extremity was effectively blocked by a buffer line of traps covering a neck of land about 30 feet in width. Traps were arranged to indicate the direction of travel of any small mammal caught crossing the line.

The islet was saturated by traps at five-yard intervals and trapping was continued for a twelve-day period which commenced June 9 and was terminated June 20. No animals were

taken after June 16 and the total population inhabiting the area was considered trapped off.

A total of ten Peromyscus was caught, represented by seven males and three females. Seven Sorex taken were represented by four males and three females. Statistically, in both cases there was no significant preponderance of either sex, indicating in the case of the Sorex, that population dynamics may not have been comparable to those on the main island.

The densities calculated from the data gathered on the islet indicated 13 Peromyscus per acre, as compared to 18 per acre on the main island, and 9 Sorex per acre as compared to 13 on the main island. The figures for the small islet may be regarded as reasonably accurate. I have little doubt that every small mammal vulnerable to trapping was caught. I am equally confident that no influx had taken place.

The agreement observed between main island and islet population densities may justify, to some extent, the arbitrary methods utilized in the areas where an influx from outside the plots presented such a grave source of error. Limited replications, differences in absolute sex ratios, varied habitat dispersion, and the strong possibility that the unequal size of the land masses had exerted differences in reaction imply, however, a need for caution.

The data presented here serve in directing attention to the existing possibilities of testing small mammal census methods on British Columbia's coastal islands.

Outline of Mammalian Fauna Observed on the Goose Islands

The terrestrial mammalian fauna of the Goose Islands at the time of study was restricted to five species of small mammals. These were the white-footed mouse (Peromyscus maniculatus), the long-tailed vole (Microtus longicaudus), the dusky shrew (Sorex obscurus), the silver-haired bat (Lasionycteris noctavigans), and the little brown bat (Myotis yumanensis).

That a species of beaver had once inhabited the islands was apparent from evidence in the form of dam shells and cuttings. No fresh sign or live animal was observed. The species is assumed to be Castor canadensis.

Marine mammals recorded during the time of study included finback whale, humpback whale, Dall's porpoise, sea lion, fur seal, and hair seal. That other species occur is highly probable but none was observed.

Marine mammal studies were confined to observations of date and place of occurrence, and are presented as such in this paper; no discussion of distribution is given. For some inexplicable reason, mink and otter apparently do not occur upon the Goose Islands. No indication of their presence, immediate, or in the past was found by our field party. Local fishermen, trappers, and Indians state flatly that they have never seen individuals of either species on the islands, or in immediately adjacent waters. No record exists in British Columbia Game Department fur return files (H. Rose, Pers. Comm.) and the island is not included on a registered trap line as many other coastal islands are.

With the proximity of large mink populations on the Broken Islands, and Bardswell group, and in light of numerous records of otter from these neighbouring islands, it is puzzling indeed that some record of occurrence has not been made. The Goose Islands are utilized by salmon and cod fishermen the year round and by local sportsmen in the fall. A scarcity of human observers does not appear to be the answer.

Ample food for both species in the form of crabs and shore fishes abounds in the coast littoral of the Goose Islands.

DISTRIBUTION OF SPECIES OF MAMMALS OF GOOSE ISLAND IN TERMS OF HABITAT OR FLORAL ASSOCIATIONS

BEAVER--*Castor canadensis* Kuhl.

Beaver populations had apparently been restricted to the mature coniferous forest and muskeg habitats where sufficient water was available. No evidence was found in other habitats. Rivulets bordered by grasses and intruding into the coniferous forest from the meadows of the lagoon were dammed at the forest edge.

SILVER-HAIRED BAT--Lasionycteris noctivagans (Le Conte).

Few observations were recorded for silver-haired bats on Goose Island. In all cases this species was seen only in the immediate vicinity of the upper mature coniferous canopy. Mature coniferous forest afforded the only available roosting sites for species of bats on these islands.

LITTLE BROWN BAT--Myotis yumanensis (H. Allen).

This small species of bat was observed for the most part in the immediate vicinity of the coniferous forest. On several occasions however, it was seen foraging over the coast littoral, sandy sea beach, and meadow habitats.

WHITE-FOOTED MOUSE--Peromyscus maniculatus (Wagner).

Peromyscus were found occupying every habitat bearing cover which occurred upon the Goose Islands. Individuals of this species were more evenly distributed throughout the habitats than were Microtus and Sorex. Of the 136 adult Peromyscus taken in the course of the quadrat works 46.79 per cent were caught in beach debris. 25.50 per cent were taken in the coniferous forest, 17.38 per cent in the muskeg, and 10.29 per cent in the meadow (Fig. 15).

Calculated per acre density estimates for this species based on the methods previously discussed are as follows: Beach debris, 56; mature coniferous forest, 25; muskeg, 18; and meadow habitat, 12.

LONG-TAILED VOLE--Microtus longicaudus (Merriam).

Microtus were taken in all vegetated habitats with a strong preference for meadow indicated. Thirty adult animals taken were distributed as follows: 13.33 per cent in beach debris, 06.67 per cent in coniferous forest, 10 per cent in muskeg, and 70 per cent in the meadow habitat (Fig. 15).

DUSKY SHREW--Sorex obscurus Merriam.

Sorex were also caught in every habitat bearing vegetation. Fifty adult animals were taken on the quadrats: 27.78 per cent of these were in beach debris, 11.11 per cent in the mature coniferous forest, 11.11 per cent in the muskeg, and 50 per cent in the meadow. habitat (Fig. 15).

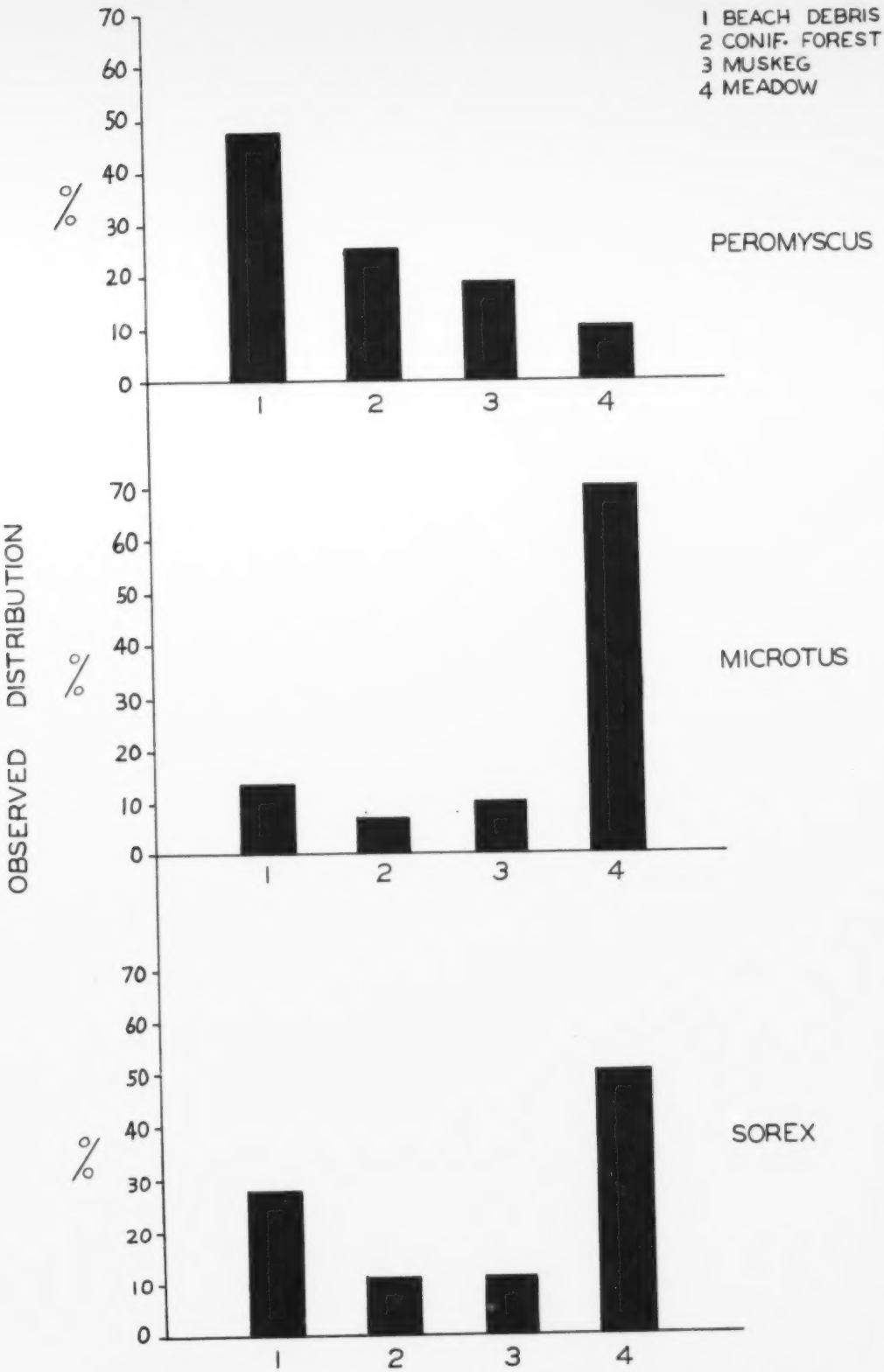

Fig. 15. Relative abundance of small mammals in four habitats on Goose Island based on snap-trap quadrat results.

Calculated density estimates indicated 13 Sorex per acre in the beach debris, 5 in the mature coniferous forest, 5 in the muskeg, and 23 in the meadow habitat.

COMMON FINBACK WHALE--Balaenoptera physalus (Linnaeus).

Six finback whales were observed, the first on May 30. Two were observed together on June 13, one on June 15, and two at widely separated points on June 26.

The animals observed on May 30 and June 15 were in the littoral waters of Goose Island, the remainder were observed in pelagic waters approximately 14 miles to the west at the edge of a shallow area termed the Goose Island banks.

HUMPBACK WHALE--Megoptera novaeangliae (Borowski).

One humpback whale was observed in coast littoral waters on July 31.

DALL'S PORPOISE--Phocoenoides dalli (True).

Dall's porpoise was first observed on June 25. Prior to that date none had been seen despite a constant vigil maintained in view of collecting specimens. On June 26, a school of eight was seen in the littoral waters on the east side of Goose Island. From July 8 until we left the islands at the end of August, several schools, numbering from three to twenty individuals occurred almost daily in Queen's Sound.

These animals remained close to the east side of the Goose Islands in the early and mid-morning period. At this time they appeared playful and disported readily in close proximity to the prow of the boat. Later in the day, the schools appeared to break up and proceeded to the central part of the sound. At this time they generally avoided the boat and were more difficult to approach.

Advantage was taken of these habits in securing specimens and photographs.

Despite comparable time spent in pelagic waters only one occurrence was recorded for the species in that habitat. A school comprised of eight individuals was observed 18 miles to the south

of Goose Island in an area termed the South bank. All other observations were made in coast littoral waters. No animal of the 140 Dall's porpoise recorded in the course of this work differed in size to the extent that it would have been placed in a separate age class. That is to say, the animals observed were apparently all adults.

SEA LION--Eumetopias jubata (Schreber).

Four sea lions observed in the coast littoral waters of Goose Island in May were probably wandering animals from nearby Whitecliff reef where a rookery harbouring between 30 and 40 individuals is situated. A single observation of the species in pelagic waters was made on June 26 at the South bank. This animal, a large bull, was robbing cohoe salmon from trolling gear of fishermen operating in the area.

FUR SEAL--Callorhinus ursina True.

Two small female fur seals were seen on May 18. One animal was observed in pelagic waters approximately 18 miles south west of Goose Island. This individual was swimming actively and appeared to be migrating. The second observation was made in coast littoral waters, where an animal was seen resting on the water approximately two miles west of Gosling rocks.

HAIR SEAL--Phoca vitulina True.

Adult hair seals were present in the coast littoral waters of Goose Island throughout the period of study. None was observed in pelagic waters.

A female and two pups were seen in the lagoon at high tide on August 11, and a yearling female was collected by Martin in the same area on August 12. The stomach of this specimen contained the remains of small fish identified as a species of perch.

GENERAL DISCUSSION OF THE OBSERVED DISTRIBUTION OF TERRESTRIAL MAMMALS UPON THE GOOSE ISLANDS

BEAVER--Castor canadensis

A series of ancient washed out beaver dams was found on the west central muskegs of the island. These had, at one time, blocked the rivulets connecting various pot holes to a considerable extent, apparently forming bodies of relatively shallow water to supply the needs of the species.

Along the eastern shores of the lagoon, the streams draining the muskeg and passing through the coniferous forest had been dammed forming several small, deep beaver ponds in the coniferous forest. Unlike the dams of the muskeg, the coastal structures have withstood the ravages of time, due probably to the more substantial materials available for their construction in this habitat or perhaps, to a later period of occupancy.

It was impossible to determine accurately to what extent these animals were distributed in the two habitats occupied. A limited number of suitable dam sites existed in the coniferous fringe. The central muskegs probably presented a larger area of sub-optimal range, and may at one time have supported a widely dispersed population of considerable size. Individuals of such a population would have been forced to forage some distance for the hemlock, red cedar, and jack pine which comprised their chief sources of food judging from the cuttings observed.

The coniferous habitat utilized appears to have been the more nearly optimal range for this species upon the Goose Islands. Food was available closer at hand, escape facilities were probably enhanced by deeper waters. The dams were more substantial and probably less subject to "wash outs" than those on the muskeg appeared to be. From the evidence it appeared that the sites at the coniferous forest edge had been occupied more recently than had those of the interior, indicating perhaps, that the species had made their last stand in this habitat.

Factors leading to the disappearance of beaver from the Goose Islands present a problem that may never be fully solved. In the lack of willow, poplar, and other conventional beaver foods, it may be argued that the habitats occupied do not represent adequate

beaver range. The precarious tenure of a species on marginal range need not be elaborated here. It suffices to say that such populations are more vulnerable to a catastrophe of climatic or biological nature than are those inhabiting optimal range.

Beaver sign, to a greater extent than was found upon the Goose Islands has been observed on many of the coastal islands. Martin and I found considerable fresh and old sign on Princess Royal, Hunter, and other islands in 1948. In 1936 H. M. Laing and I found evidence of still extant populations on Calvert Island, as did McCabe (1948). The abundance of sign presents two possibilities, first that a large population once existed on optimal or near optimal range represented by the habitats on these islands, and second, that these habitats represent marginal range occupied by small populations which are forced to re-establish over periods of time, leaving in their wake an abundance of lasting sign that is difficult to age accurately. In these respects, until an adequate study has been made, I am inclined to agree with McCabe and to regard the coastal islands on the whole as marginal range for beaver.

This marginal concept holds true especially for the Goose Islands, where area, fresh water, and deciduous growth are much more limited than on the inner islands.

Man may have been instrumental, directly or indirectly, in the disappearance of beaver from the Goose Islands. About 1904 when Mr. Max Lohbrunner (1948, Pers. Comm.) first visited the islands, he observed a number of emaciated dogs digging for clams on a beach at low tide. In his opinion these animals were in the final stages of starvation: ribs showing, their feet torn and bleeding. the animals were reported to have had an air of desperation about them. They had, apparently, been abandoned on the islands by Indians who came annually to fish in surrounding waters. Certainly it can be inferred that beaver would rate more highly to a starving dog than would clams. In light of the limited escape facilities and restricted habitat on so small an island it is conceivable that these carnivores may have been a factor contributing to the disappearance of beaver there. In addition it is entirely possible that some trapper or trappers located the beaver and subsequently trapped them off. Here again the marginal aspects of the area would facilitate annihilation.

In any event, the beaver are apparently gone, no record of a living animal from the Goose Islands appears to exist. The local trappers, fishermen, and sportsmen interviewed have never seen them there and the British Columbia Game Department has no records of their occurrence.

From Mr. Lohbrunner's reports it may be safely assumed that beaver occupied the islands some time prior to 1904. Why they have failed to re-establish themselves over a period of time approaching 46 years must be left to conjecture. If the coastal islands to the east are marginal range which once forced an extensive wandering of individuals when populations were unmolested by men, it is possible that augmented trapping along the mainland coast and inner islands annually reduces the number of surplus animals, thus eliminating a possible population pressure that may have led to the original occupancy and additional restocking. On the other hand the original stock may have arrived accidently and subsequently disappeared, due to such inadequacies of the environment as land mass, food, and so on. In this case any future occupancy is left purely to chance, may possibly be temporary, and seems to furnish a more plausible explanation for the length of time which has elapsed since beaver lived upon the Goose Islands.

SILVER-HAIRED BAT--Lasionycteris noctivagans

Population studies of Lasionycteris and Myotis were confined to nightly observations and to some field collecting.

The silver-haired bat was recorded only five times in a period of almost continual nightly observations extending from May 23 to July 21. One specimen was taken, an adult male collected on June 12 which constituted the first observation. Four observations were subsequently recorded, the last on June 30.

In all cases this species appeared earlier in the evening than did Myotis. It fed at a high level, usually above the upper canopy of the mature coniferous forest. The only apparent food was a species of small white moth which became active in the late afternoon.

The prevailing westerly winds that often blew throughout the night during the summer months probably influenced the activities and distribution of this species and may account for the lack of an appreciable population upon the Goose Islands.

LITTLE BROWN BAT--Myotis yumanensis

In the same period of observation maintained for Lasionycteris 24 observations of the little brown rat were recorded. Five specimens were collected, four adult females and one immature male. A female taken June 1 carried an embryo 13 mm. in crown-rump measurement. Myotis were observed first on May 23 and were still present on the last day of observations, July 21.

This species appeared later in the evening than did Lasionycteris. It fed generally below the canopy of the coniferous forest, flying low along the edge or through clearings in the trees. On several occasions when no wind prevailed it was observed at distances up to 150 yards over the sea, skimming low over the water and about exposed reefs, feeding apparently upon flying insects of some kind. The white moth utilized by Lasionycteris was also taken by this species. On other occasions Myotis were observed over the sandy sea beaches and neighbouring meadows about the lagoon.

Compared to the mainland and inner island populations Myotis was poorly represented upon the Goose Islands. This was probably due to wind effect as in the case of Lasionycteris. Myotis populations on Goose Island, however, are apparently much higher than those of the larger bat. This seems to indicate that this little bat is influenced less by wind than is the high-flying, open-feeding Lasionycteris. The low-flying habit coupled with the ability or preference to hunt through the forest as well as above it or along the edge, probably has an effect upon the distribution of this species. Previous observations along the coast and coastal islands, seem to substantiate these conclusions. Areas affected by heavy prevailing winds are inhabited by much smaller populations of bats than are the sheltered areas, and species of Myotis appear to be much more generally distributed throughout coastal British Columbia than is Lasionycteris.

WHITE-FOOTED MOUSE--Peromyscus maniculatus

It is generally conceded that males of this species and closely related forms range farther in their nightly wanderings than do females. No methods of measuring this alleged difference was possible in this research. No significant difference at the .05 level of probability was observed in the sex ratio of total animals trapped. Seventy-five were males and sixty-one were females. If one is to accept the generalization postulated above the observed sex ratio

would indicate a preponderance of females. However, the species has never been studied critically in this respect on the British Columbia coast where the ecological conditions vary greatly from those of eastern North America where most of the Peromyscus studies have been conducted. In view of the fact that an insignificant preponderance of males in the total catch is generally reflected in each habitat and in each plot within these habitats, I see no alternative other than to accept the figures at face value and to assume that they represent the distribution of sexes throughout this species in all habitats on the Goose Islands. In other words, the observed difference, a preponderance of 14 males, may be regarded as the result of a greater range in the male of the species. Statistically, however, no significance can be attached to this observed difference so a balanced sex ratio is accepted and regarded as normal for population of Peromyscus maniculatus inhabiting the Goose Islands.

The apparent preponderance of this species in the beach debris may be attributed to a number of ecological factors. The beach affords a wide variety of foods at the season this study was made. An abundance of vegetative foods was growing on the high beach, Lathyrus, Potentilla, and Vicia being utilized by Peromyscus. Cuttings were found near which the droppings of this species were observed; and traps set in such places invariably yielded mice. Additional food in the form of amphipods, crabs, limpets, and a host of beetles and other insect life was also in abundance. While no direct evidence indicated the utilization of amphipods as food by Peromyscus they do form a potential supply in this habitat. Limpet and crab remains were found wherever the habitat favoured their occurrence and these may be regarded as a regular part of the diet of coastal Peromyscus.

The availability of dry home sites is ideal on the high beach, and while no predation apparently exists, escape facilities in the maze of interwoven logs may possibly have fulfilled some inherent need of the species here. Dry sphagnum in abundance may have been utilized for nesting material. Most species of mammals indulge in activities which may be intepreted as play. I believe this activity in Peromyscus takes the form of unimpeded romps over open stretches of ground. Tracks in the sand and previous observations would so indicate, at any rate. If this is true, the beach affords running grounds of unsurpassed excellence.

This combination of abundant and varied food supply, availability of nesting sites, materials, and escape facilities, open ground for play coupled with the general dryness at this season probably accounts for the apparent preference of Peromyscus maniculatus for beach debris habitat on the Goose Islands..

Fresh sign in the form of droppings was very abundant in the beach debris. Old sign was lacking. Mouse droppings, of course, in the wet coastal belt, must be well sheltered in order to last more than a few hours. The high relative humidity will cause deterioration in a very short time even when such droppings are protected from direct rainfall. Careful examination in the drier recesses, however, sometimes reveals droppings--which, when compared to the more recent material may often be identified as winter sign. When such droppings are accompanied by runways, grass cuttings and lasting sign of this nature it is often possible to state definitely whether or not the sign was made during the previous winter. No winter sign was found in the beach debris habitat, indicating that the population present in May and June may well be absent at other seasons of the year. The abundance of fresh sign, substantiates the trapping results obtained here. Myriads of fresh tracks in the sand, fresh droppings and runways of Peromyscus were much more in evidence than in the other habitats studied. While I do not profess to know how much sign one mouse leaves in a given length of time, I do maintain that by careful examination an experienced operator can very often distinguish between an area greatly utilized by mice and one which is not. That Peromyscus utilized the beach debris to a far greater extent than the other habitats at this time of the year seems quite apparent.

The trapping data, again substantiated by sign, indicated that utilization of coniferous forest by Peromyscus was less by half, than it was in the beach debris. Winter sign, however, in the form of cone cuttings was very abundant on the forest floor while fresh sign was difficult to find. That a heavier population had previously occupied this habitat appeared obvious. Three possibilities immediately come to mind in this respect. First, that the annual increment of young animals born in the summer and fall months is forced into less favourable habitats by population pressure, and that the observed populations represent, in part, those which have survived the winter. Second, that a much higher population had recently occupied all habitats, representing a possible population peak which had recently entered a decline resulting in heavier

populations surviving in more optimal range represented by beach debris. The third possibility is that habitats bordering the sea become untenable during winter periods of high tides, great storms and limited growth, in which case the coniferous forest and muskeg become more optimal.

The concept of recent population decline may possibly be validated by the universal dispersal of winter sign observed throughout the coniferous and muskeg habitats. These habitats covered a far greater area than did the meadow and beach debris and it is difficult to attribute the amount of evidence in these areas solely to the populations observed in the limited areas of suitable peripheral habitat. In considering the high reproductive potential of the rodents involved, however, it is entirely possible that the annual increment of young could, in a season of high productivity, universally "flood" the areas of forest and muskeg to the extent indicated by the winter sign observed. On an island where the limiting factors appear negligible in the summer months, it seems logical to assume that a large part of the evidence found can be attributed to the annual increment. The possibility that such evidence may have been augmented by a recent decline in total population remains. To what extent this factor influenced the amount of evidence found cannot be measured from the available data.

From a purely physical point of view the beach debris and meadow habitat must become untenable to small mammals during the winter months. At this season, probably from November through March, the prevalence of high tides accompanied by terrific winds and storms undoubtedly inundates the peripheral habitats for a large part of the time. Summer tides failed to flood the areas in question, but came within a very few feet of doing so. High winter tides coupled with increased ground swell, plus arrested growth, almost certainly eliminated the beach debris of Goose Island as regular winter range for small mammals.

The coniferous forest in many respects appeared to be adequate range for Peromyscus. Home sites and escape facilities in the form of fallen logs, dead trees, and windfall are plentiful, as is open ground for running. General dryness and variety of food, however, do not compare favourably with beach debris in the summer months. In winter the Peromyscus apparently feed largely upon seeds cut from the shed cones of Picea which are in abundance upon the forest floor at that season. The relative dryness of the two habitats is apparently reversed, the forest

then affording more suitable ecological niches than do the sea-washed habitats along the coast.

From these discussions it may be concluded that ecological changes occurring with the major seasonal variation probably results in a reversal of optimal conditions in Peromyscus range on the Goose Islands, leading to a population movement from one habitat to a vastly different one. The evidence indicates that the spring movement from interior to peripheral habitats occurs sometime during the month of April. The autumnal movement is probably more gradual, beginning in late summer and early fall with increasing population, and climaxed in or about the month of November with the onslaught of winter tidal and storm conditions. In periods of low winter tides and relative calm, the possibility of Peromyscus foraging from the forest edge to the beaches to supplement their diet with marine invertebrates is very real. That a population occupies the peripheral habitats regularly, however, appears extremely unlikely.

Heavier winter populations of Peromyscus were also indicated in the muskeg habitat. An abundance of winter sign prevailed under the thick cover afforded by stands of Myrica, Ledum, dwarfed Thuja, and plants of similar nature. Fresh sign was scarce and only 17.38 per cent of Peromyscus taken in the quadrats was caught in this habitat. The arguments presented in discussing the higher winter populations in mature coniferous forest apply to the muskeg as well. The degree of utilization, however, may vary with the number of young produced annually. In years of low reproduction the coniferous forest may provide adequate winter range for the total population. In years of high productivity this habitat may prove inadequate to support all of the animals, thus forcing them to forage into the muskeg, which must, in the winter season present an extremely wet and inhospitable environment despite ample seed-bearing plants. Regarded from another point of view, the populations may move in two stages, first, to the coniferous forest, and then, on depletion of the Picea seed supply, to the muskegs for food. This theory is strengthened by the fact that the evidence of winter populations using the muskeg is represented by droppings only, while in the coniferous forest cone cuttings were dominant. The inference here, of course, is that the presence of droppings indicates more recent utilization than do the cuttings in the forest.

The perpetual wetness of the muskegs, despite a superficial dryness in periods of drouth, appears to be the limiting factor to

stable Peromyscus populations in this habitat. All of the animals taken were caught near intrusions of coniferous forest indicating that the muskeg proper was used primarily as a food-foraging area by this species in the summer months. In the winter this utilization was probably intensified by increased populations inhabiting the forest which accounts for the general abundance of winter sign found. In light of these discussions it seems that the summer populations recorded as utilizing the muskegs, were in actuality based in the coniferous forest edge.

Utilization of meadow by Peromyscus was small: only 10.29 per cent of the quadrat catch was taken in this habitat. Sign in the form of cuttings or droppings was almost completely lacking, and winter sign was nil. All of the Peromyscus taken were caught in natural runways formed by rills that traversed the meadows from coniferous edge to seashore. None was taken in the heavy grasslands proper, despite the prevalence of Microtus runways. Food and homesites appeared adequate to support much greater utilization than the take indicated. The meadows, however, were basically wet and populations of large Microtus offering possible inter-specific competition may in themselves account for the low populations observed. I have no specific data regarding tolerance between the two species. Many of the Peromyscus taken in all habitats bore tail scars, indicative of fighting. No intensity of scarring was apparent in meadow Peromyscus over those in other habitats where Microtus did not abound, indicating intra-specific intolerance rather than one of an inter-specific nature.

Microtus were taken in some instances in rill sets that also caught Peromyscus, which leads to the assumption that a certain amount of intermingling of species takes place. No Peromyscus catch in the confined Microtus runways through heavy grass, however, seems to indicate that a considerable degree of avoidance might prevail and that Peromyscus confine themselves to routes in which wide berth can be given.

Any Peromyscus utilizing the meadow permanently are forced to the forest and muskegs during the winter months. The presence of large logs and other debris on the meadows and extending up to the forest edge indicates that the area must be flooded at some time to a depth of two or three feet at least. No such flooding occurred during the four months spent on the islands, although the higher summer tides came within a few inches of doing so.

The Peromyscus utilizing the meadow in summer probably had home sites in the coniferous forest edge as was the case in the muskegs. During the winter months these animals were forced to forage in the coniferous forest and muskegs as were those from the beach debris.

LONG-TAILED VOLE--Microtus longicaudus

As in the case of Peromyscus a balanced sex ratio is indicated throughout the Microtus populations inhabiting Goose Island. While differential wandering between sexes is a possibility with this species also, the figures obtained are accepted on the same bases presented for the former.

The occurrence of Microtus is apparently correlated with that of suitable grasses. The low returns recorded from beach debris, coniferous forest, and muskeg habitat indicates a distinct lack of some ecological requirement or requirements in each. These are easily explained for beach and forest where the small amount of grasses occurring yielded the only Microtus taken. Where no grasses occurred no Microtus were taken and no indication of their presence was observed. Grasses in these two habitats were confined to sporadic stands and intrusions along the edges. In the muskegs, however, grasses occurred regularly though not in the thick stands observed on the meadows. Ample cover was provided by sphagnum mosses and other muskeg-inhabiting plants. The deciding factors appeared to be the availability of suitable nesting sites and the density of the grasses. Perhaps the firm soil base of the meadow habitat is preferred to the soggy mass of ancient sphagnum which forms the base of the muskeg. Fresh burrows were numerous on the meadows, but none was found on the muskeg. The preferred summer habitat then is obviously meadow, where fresh cuttings, droppings, and burrows substantiate the trapping returns. This preference may be attributed to an optimal ecological combination of heavy grass stands affording maximum food, cover, nesting materials plus suitable bases for burrowing and nesting sites.

In the winter months the Microtus populations must leave the meadows due to flooding conditions primarily, and possibly through lack of suitable foods when the grasses are dead. No evidence of winter utilization of coniferous forest was found, but old droppings and runways were prevalent upon the muskeg. That a reversal of optimal conditions concerning Microtus occurs between the meadows and muskeg habitats in spring and fall is

indicated. Though some Microtus may utilize the coniferous forest in winter leaving little or no sign; the apparent evidence points to muskeg as the preferred winter habitat. The arguments presented in discussing population movement in Peromyscus are applicable here in many respects and are not pursued further.

Microtus are well adapted to a wet habitat, they swim readily for short distances and dig shallow burrows in wet soil along the banks of rills and small streams. Long runways are constructed through the grass along which these animals travel with amazing rapidity despite their short legs. Side runways off the main thoroughfares lead to feeding stations where the cuttings are found; in other cases the grasses are cut and carried to burrows or other points of cover where they are eaten.

Several species of grasses and sedges were being utilized by Microtus upon the islands. As specimens collected were unfortunately destroyed I am unable to present the data here. The stomachs of all Microtus examined, however, contained a green finely masticated mass of vegetable food. I found no evidence of these animals eating insects, but some specimens of Microtus and Peromyscus were partially devoured in the traps. Sorex were responsible in part for this, but in many cases rodents had apparently been guilty; whether Microtus or Peromyscus was undetermined.

Conditions prevailing on the Goose Islands in respect to Microtus, prevail as well in many areas visited on other coastal islands and on the mainland. That Microtus longicaudus is an animal of the meadows and muskegs generally holds true in coastal British Columbia.

DUSKY SHREW--Sorex obscurus

A significant preponderance of adult male Sorex was observed in all habitats except the coniferous forest. Here the sex ratio of 2 males to 1 female is not statistically significant due to the small number of animals taken, and consequently warrants no further discussion. The highly significant preponderance of males in the total adult catch, (40 males; 14 females) however, requires explanation.

A review of field data collected on the Queen Charlotte Islands in British Columbia (Guiguet, 1948) and in Algonquin Park, Ontario (M. Jackson, Pers. Comm.) reveals that the observed sex ratio in two species of Sorex studied remained balanced until the first young

were taken in the traps. After this time, (herein referred to as the datum point) a preponderance of males was observed in both cases, indicating a sex ratio of 2 to 1. When the Goose Island work was initiated young Sorex had already left the nest and while no data on the pre-datum point sex ratio were obtained it seems reasonable to assume that the phenomenon previously observed had been repeated and so accounted for the preponderance of males observed in Sorex on these islands.

The basic factors leading to the apparent unbalanced sex ratio after the young are observed, remain, as yet obscure. Present studies being conducted at the University of British Columbia by Miss Mary Jackson may clarify the issue. From the evidence to date it appears that a lower viability in breeding adult females may be the answer in part.

Some species of shrews apparently die after one breeding season in which they breed twice (Asdell, 1946). A post-partum heat occurs requiring extensive coitus to effect fertilization. It may be argued that at this time the females are sedentary and the males extremely active, resulting in a larger catch of the latter sex. In the populations studied on the Queen Charlotte Islands no pregnant females were caught after the datum point, which seemed to indicate that the populations there may have bred only once up to the end of August when trapping was discontinued. Only one pregnant female was taken on the Goose Islands and this animal was caught early in May indicating that the same conditions prevailed there in this respect. Since an equal number of males and females were taken prior to the datum point, and since the great majority of these females were lactating or carrying embryos, it seems illogical to attribute the observed preponderance of males to differential wandering--otherwise this preponderance should have been apparent in the pre-datum period of trapping as well. If the males in actuality wander farther throughout the year than do the females, it is obvious that trapping returns indicating a balanced sex ratio should be interpreted as reflecting a preponderance of females, other factors remaining constant. In this respect the post-datum sex ratio should probably be interpreted as indicating a more evenly balanced sex ratio at that time. The situation in respect to the observed number of females before and after the datum point does not alter. The fact remains that significantly fewer females are observed after the young appear.

A change in susceptibility to trapping between sexes due to the effects of breeding, seasonal advance, or both may be a factor influencing the observed sex ratios. It is entirely possible tnat females after breeding become more cautious, undergo changes in diet, or suffer some similar reversal in habit which may result in a smaller catch.

Diurnal activity manifested by trapping returns revealed that for every two males taken only one female was caught. On the Goose Islands only nine adult Sorex in the total catch of 54 were taken by day. On this basis greater diurnal activity in the male cannot be considered as a factor influencing the observed sex ratio.

If a complete annual turnover in population occurs on the death of the adults at some time between the end of the breeding period and the following spring, it is not unlikely that the female, due to the drain imposed by the bearing and nursing of young, would, in a species of such high metabolic rate, succumb earlier than does the male. It appears highly probable, therefore, that the underlying cause or causes leading to an observed preponderance of males after the young begin to run is tied in closely with breeding activity. Just which aspects of breeding are involved remain unknown and require further investigation.

The observed distributions of Sorex populations upon the Goose Islands is difficult to explain satisfactorily. The factors contributing to the suitability of an environment for a given species depend largely upon available food, climate, humidity, cover, and a variety of such conditions which man is often unable to measure accurately. In the case of Sorex practically nothing is known of these requirements.

In analyzing the distributional data gathered in respect to this species it appears obvious that the refinements of technique in the assessment of Sorex range were inadequate.

It has been postulated that a micro-environment of high humidity is probably an essential requirement for the survival of these animals. Based on observations of captive specimens, the only degree of success in maintaining individuals occurred when they were kept in terraria under humid conditions (Dr. I. Mc.T. Cowan, Pers. Comm.). On the Goose Islands from gross inspection, the meadow, muskeg, and coniferous forest must all be classified as humid. The beach debris on this basis was comparatively dry. Yet the concentrations of Sorex occurred in meadow

and in beach debris. From these observations it may be assumed that, first, humidity is of secondary importance in determining distribution, or second, that the apparent humidity of the four habitats observed by gross analysis was not reflected in the micro-habitats; this implies that the methods of appraisal were inadequate. I believe the latter to be the correct assumption.

In considering available food as a factor, the insectivorous nature of Sorex must be kept in mind. I have no record of these animals utilizing vegetable materials as food. Certainly the morphological aspects are those of the insectivore. Through necessity, the appraisal of the relative abundance of insect life throughout the habitats occupied by Sorex was also one of gross examination. A varied abundance was observed in the beach debris; forest and muskeg harboured noticeably fewer insects, while the meadow habitat, though examined more minutely in the course of point sampling, appeared least productive of all. The highest concentration of shrews, however, occurred in the meadows. It was assumed that despite an apparent lack of insects there must have been sufficient food to support the populations observed. Consequently the relative abundance of insects apparent in the different habitats cannot be used as a factor in explaining the observed distribution of Sorex.

Assuming that food supply and conditions of humidity were comparable and adequate in all habitats, exposure to sunlight may be considered. In this respect beach debris, muskeg, and meadow appeared equal, yet the distribution of Sorex varied greatly in all three. In addition this factor may be of little direct consequence to nocturnal species.

Inter-specific intolerance is eliminated as an influencing factor on the basis that Sorex was constantly taken in the same traps which caught Peromyscus and Microtus. Apparently no competition existed for food while competition in other respects remains unknown.

On this basis of gross examination, the cover type of the meadow represented by lush stands of grass was the only observed difference that could be considered as a contributing factor in the observed distribution of this species on the Goose Islands. In view of inadequate knowledge pertaining to the micro-ecological factors associated with gross observed differences in habitat, however, no reasons for the observed distribution of Sorex can be postulated here with any degree

of confidence. Further investigations into the life history and behaviour patterns of these diminutive animals are indicated.

Sorex inhabiting the peripheral habitats must necessarily have left those areas in winter as did the rodent species. The evidence left by shrews is minute and subject to rapid disappearance, consequently traces of their occupation in the winter months were obliterated. The seasonal activity of annual young may be assumed to parallel that of the other two species, although a complete annual turnover in population may result in fundamental differences.

THEORIES ON THE ORIGINAL OCCURRENCE OF INSULAR MAMMALS IN BRITISH COLUMBIA

Any investigator, having travelled for hours over stretches of cold Pacific seas to reach a small islet, invariably, upon finding it occupied by small mammals, begins to speculate upon the manner in which those animals have negotiated the formidable expanses over which he has just travelled in a modern vessel.

From these speculations four main theories have developed. Two of these require substantiation by a more complete geological picture of the coast as it was during, and at the close of the last glacial period; another requires a more detailed knowledge of tidal currents, while the remaining may rest forever in the field of conjecture.

These four theories are, in the order presented:

1. That residual populations lived through the ice age in unglaciated insular areas and survived to repopulate the glaciated portions as the ice withdrew.

2. The concept that the retreat of the ice left temporary ice bridges that may have been vegetated, over which the ancestors of the present populations migrated.

3. The "slide" theory postulated by McCabe and Cowan (1945) in which evidence of ancient and recent land slides are pointed out. These slides bearing acres of vegetation were borne off

on the tides, carrying with them mammals and other forms of life, which ran ashore when the rafts eventually lodged--possibly on distant islands.

4. The theory of human transportation. Large populations of Indians inhabiting the coast and moving seasonally to fish on insular groups, may well have transported certain species of mammals to those groups where they have subsequently become established.

The complexity and variation of the islands and channels along the British Columbia coast may be forcibly brought to the reader's attention by a glance at any map of the area. That any one or all of the postulated factors may have been instrumental in distributing the animals as they appear today, is highly probable. In cases where it is practically certain from geological evidence that an island was completely below the sea, arising only after the disappearance of the ice, the concepts of residual population and ice bridge are eliminated. In other cases, however, this appears to be the only plausible theory. Recent investigations by the University of British Columbia on outer isolated islets of the Queen Charlotte group reveal small mammal distributions that can be logically explained only on this basis. The indigenous caribou of Graham Island is another case in point.

McCabe and Cowan (1945) point out the plausibility of the floating slide (Fig. 16) as an agent of distribution. On considering the geological history of the Goose Islands this appears to be the most logical explanation for the presence of small mammals there. The group has long been utilized by the Bella Bella Indians as a summer fishing grounds; that the animals present may have been transported in canoes loaded with household materials is a possibility, certainly a very real one in the case of the ubiquitous Peromyscus. In the case of Sorex and Microtus, however, the reality lessens. Where larger mammals are involved the plausibility of the aboriginal as an agent of dispersal decreases. Bears are alleged by many to have arrived upon the Queen Charlottes in this manner, transported as pets while young. The mountain goats inhabiting Pitt Island are said to have been taken there from the mainland in comparatively recent times by some Indian chieftain. These two allegations today are little more than rumour, whether their status will ever assume a more definite rating is very doubtful.

As one views the range in degrees of speciation manifest by morphological characters through the insular races of a given species

(Peromyscus maniculatus), the question of re-invasion is immediately presented. The possibility that such re-invasion or series of re-invasions could attain sufficient magnitude to effect phenotypical expression seems remote on such well isolated groups as the Goose Islands. In the closer network of the inside islands as well, the nature of the separating channels discourages such a concept.

It will ultimately be shown, as our knowledge accumulates, that some of the factors postulated above are more logically applicable to one island, or group of islands than they are to another. For the main part, however, the insular complex lying along these shores is made up of well isolated units presenting unsurpassed opportunities of study in the field of isolation and speciation (Fig. 17).

AVIAN POPULATIONS

Methods of Study

For purposes of bird study the habitats as designated in the mammal work were utilized. These habitat types based on floral or physiological characters (as in boulder beach, tidal flat) were found to be fully adequate and convenient for the avian work as well. Our aim here was to determine the relative numbers of the different species in the different habitat types.

On May 11, daily general reconnaisance was undertaken in order to familiarize the observers with the area and general distribution of the various species of birds occurring. In this work each observer recorded the number, kind, and habitat; each observation was to be regarded as a unit in calculating the relative abundance of the various species. On June 11, it was felt that a series of plots should be run in the major avian habitats harbouring indigenous birds. Our reconnaisance had shown that the edge of the coniferous forest at the sea appeared to be the preferred habitat for most species of resident birds. In order to draw up comparisons, a series of plots selected at random, were run in this habitat, in the coniferous forest, at the junction of forest and muskeg, in the muskegs, and in the meadow habitat. Habitats such as the rocky seashore, tidal mud and sand flats, boulder beach were utilized primarily by migrating

shore birds. In assessing these no plots were utilized but records taken on general reconnaisance throughout the summer were analysed and conclusions drawn. Since migrants in the passerine species were gone when the plot work began conclusions thereon are also based on full summer general reconnaisance. The pelagic community presented a comparatively simple problem. The total number of trips on pelagic waters was not great. We simply recorded every bird seen, and based the relative abundance of different species upon our observations. In studying the sea birds we found it useful to "chum them in" for close observation. By dropping bits of oily halibut liver, pieces of fish, and broken up biscuits a "train" of gulls soon followed along in the wake of the slowly moving vessel. Other pelagic species otherwise difficult to approach were in this manner often attracted to within gunshot.

For the purpose of this work migrating birds are termed such in relation to the Goose Islands: the term simply designates species that passed through and did not stop there to nest. Indigenous birds, also, indicate birds that remained the summer on the Goose Islands--many of these species are migratory species. Our prime interest, as previously stated, was to determine the kinds of birds that utilized the Goose Islands in the summer months and to determine their relative abundance in the habitats occurring. In order to systematize, the following methods were used.

Plots 150 yards long by 50 yards wide were divided into five stations. Two observers ran each plot simultaneously, that is, together. At each station one minute of silent observation was undertaken and the birds recorded. Two minutes of low pygmy owl-calling was then undertaken in order to draw out any birds that may have been skulking unseen. The additional birds were added to the list for that station. In this manner we felt that all birds in the 50-yard strip (25 yards on each side of the line of operation) were accounted for. From previous experience, both Mr. Martin and myself concluded that at 25 yards the owl call was effective, and, in fact, beyond this distance little response was noted. Birds at previous stations along the strip were often still there when the last station was being worked. Sources of error in repetition, possible lack of response to owl calling, different reaction of the various species occurring, varying weather conditions--particularly wind, were carefully considered. For all practical purposes, however, we feel the results attained presented a fairly accurate picture of the relative abundance of the species of birds

Fig. 16. A recent slide on northern Vancouver Island where thousands of feet of soil and timber slid into the sea.

Fig. 17. One of the small isolated islets harbouring mice; in the Goose Island group.

occurring in the different habitats. The above method was utilized in coniferous forest edge at the muskegs. In the muskegs habitat plots 100 yards by 100 yards were utilized. Two operators took up station in the centre of the plot and noted all birds using the area during a 15-minute period. Visibility was excellent in these areas as practically no adequate cover existed. Consequently any bird moving could scarcely be overlooked. In the meadow habitat no plots were utilized, that area being barren apart from the occasional song sparrow, and these frequented the edge for the large part.

In analysing the data accumulated in the above manner, it was apparent that the great majority of birds of most species frequented the edge of the coniferous forest facing the sea while the inner edge, along the muskegs, the coniferous forest, the muskeg proper, and the open meadows were practically birdless apart from a few individuals of certain species.

To eliminate long verbal description, the results attained are presented here in the form of bar diagrams which, we feel, are self-explanatory (Figs. 18, 19, and 20). In addition an annotated list of birds has been prepared, as well as a check list to the subspecific level where specimens were secured.

ANNOTATED LIST OF BIRDS OF THE GOOSE ISLANDS

LOON--*Gavia immer* (Brunnich).

In May common loons were observed regularly along the east coast of the Goose Islands in what appeared to be a northward movement. After the end of that month occasional birds recorded were probably individuals nesting on some of the larger islands to the north and east.

On July 4 at Broomfield Lake on Princess Royal Island a pair of breeding adults was observed with two downy young. The young when collected, proved to be male and female.

Observations on this species are presented graphically under migratory birds as the great majority of birds observed were non-residents.

ARCTIC LOON--Gavia arctica (Linnaeus).

A large migration of Arctic loons passed the Goose Islands in May and early June. They were observed regularly, moving north in small groups of two to six birds. Upon one occasion at the north end of the island, a large flock in excess of 200 individuals had stopped, evidently to feed, as much diving activity prevailed.

No records of nesting were secured for the species in the area and after June 9 they were not seen about the Goose Islands.

RED-THROATED LOON--Gavia stellata (Pontoppidan).

Red-throated loons remained in the vicinity of the Goose Islands throughout the summer. They were observed daily and often heard in flight over the north central part of the island where a small lake was situated.

Throughout May and early June a regular morning flight of six to eight birds passed between Goose and Gosling Islands, headed in a westerly direction. In the evening about 4 p.m. a similar flight moved to the east. It is believed that these birds nested on the islands to the east. As evidence in support of this a pair with large downy young was observed on Spider Island on July 30. The two young birds collected were male and female.

The red-throated loon is classified as a resident bird in this work although one large group of 60 individuals was obviously passing northward on May 31.

GREBE--Colymbus species.

That no grebes were recorded during our stay on the islands is noteworthy.

BLACK-FOOTED ALBATROSS--Diomedea nigripes Audubon.

These large pelagic birds were seen regularly in small numbers on the Goose Island banks. In May during the halibut season they were observed feeding upon offal discarded by the fleet and were reported as numerous by fishermen at that time. Through June and July they were dispersed and seen only as singles. A lone individual was observed on August 16, the date of our last visit to pelagic waters.

Fig. 18. Relative abundance of indigenous birds observed on Goose Island, summer 1948.

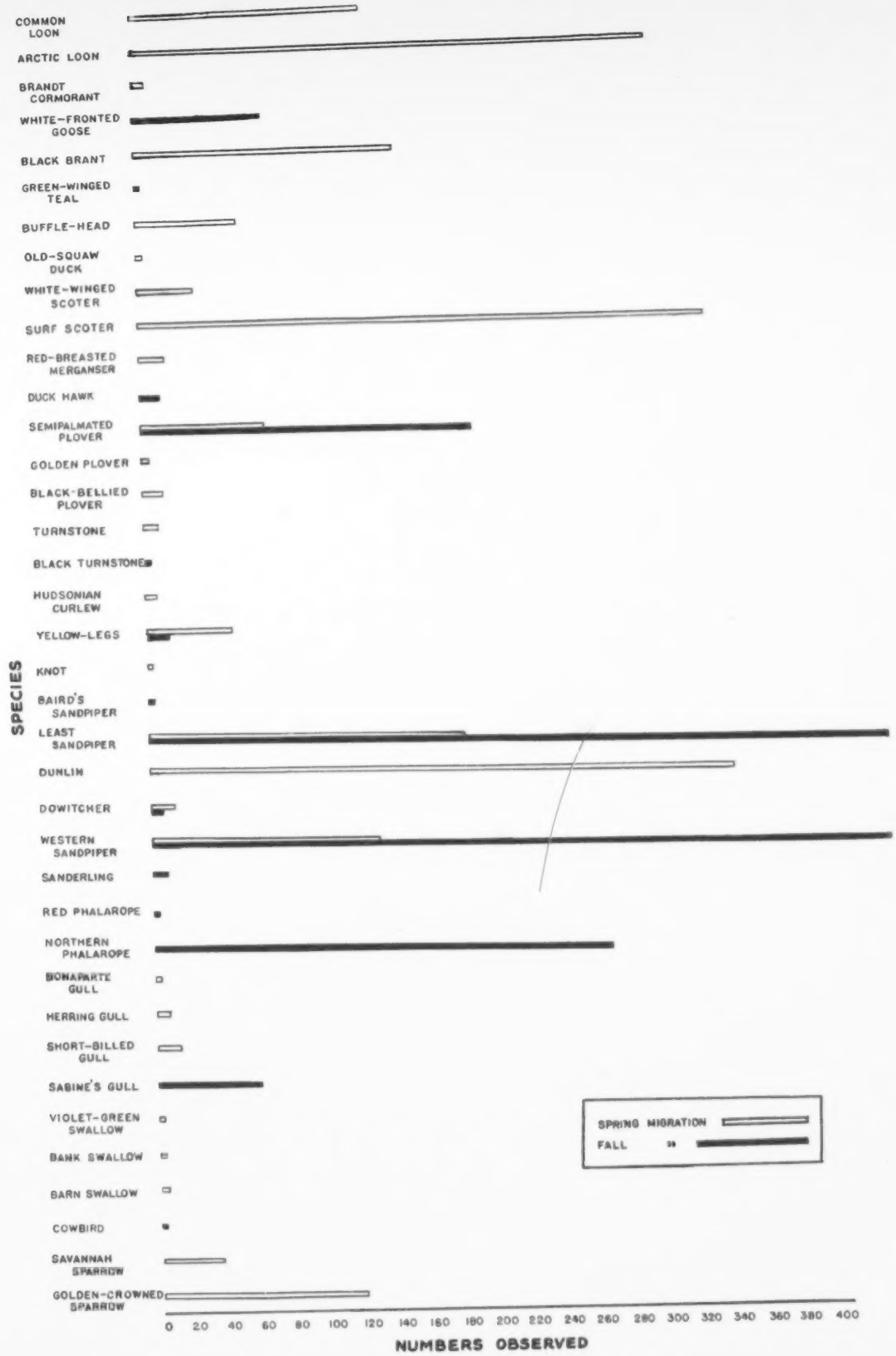

Fig. 19. Relative number of birds observed migrating at Goose Island, summer 1948.

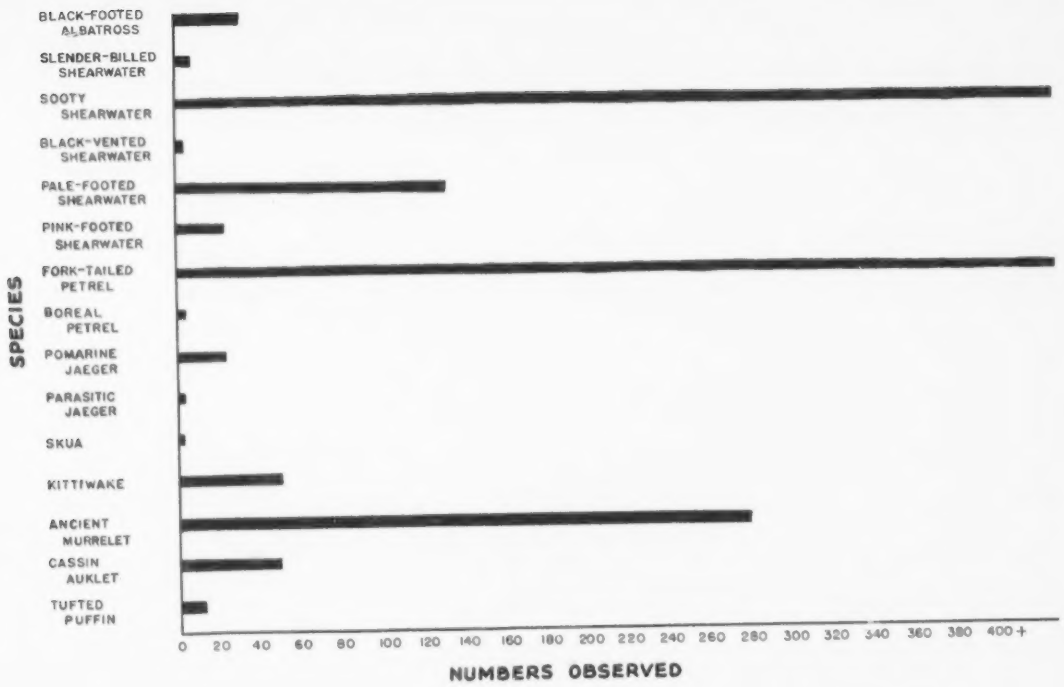

Fig. 20. Relative number of birds observed on pelagic waters near Goose Island, summer 1948.

The albatross usually foraged beyond a point 10 to 18 miles off the coast but on foggy mornings and in periods of very rough weather individuals were sometimes sighted from the shore.

SLENDER-BILLED SHEARWATER--Puffinus tenuirostris (Temminck).

These birds were uncommon on the Goose Island banks. An adult female collected on June 26 about 16 miles west of the island was the only specimen record secured. This particular bird sailed in and landed among a number of sooty and pale-footed shearwaters on "chum" behind the boat, where it stood out distinctly. Brood patches were still apparent and the plumage was in good condition, indicating perhaps that this individual had only recently arrived from the breeding grounds below the equator.

Five dark slender shearwaters seen at intervals up to July 27 were listed as of this species.

SOOTY SHEARWATER--Puffinus griseus (Gmelin).

This was the most common bird seen on the pelagic waters. It was present in very large numbers upon our arrival in May and appeared equally as numerous until August 16, when observations were discontinued.

Specimens collected in May had bare brood patches and were beginning to moult. The plumage at this time was dull brown and worn. By mid-July the primaries were glossy and black differing markedly from the worn contour feathers. By August 13 most of the shearwaters appeared very dark, and specimens collected on that date had almost completed the moult.

These birds fed throughout the summer months upon sand lance which surfaced on the banks at regular intervals. When a school appeared the pelagic bird community moved in "en masse," shearwaters arriving, it seemed, from over the horizon. On several occasions the birds so gorged themselves that flight seemed impossible; they dived or scurried off with a peculiar side to side wobble as they cleared way for our vessel.

Several shearwaters were captured by hook and line. A barbless hook, nylon line, and a geared reel was used. The baited hook was dropped astern and the reel thrown out of gear. The free-running nylon allowed the bait to remain still as the boat

slowly pulled away. When the bait was 50 or 60 feet out the shearwaters would rush it, one invariably being caught by the bill. The escape procedure then was to dive not to fly, and a surprising force was exerted by the bird, often stripping line off the reel.

BLACK-VENTED SHEARWATER--Puffinus opisthomelas Coues.

A lone individual seen about 18 miles southwest of the Goose Islands was the only record of this species in the area.

PALE-FOOTED SHEARWATER--Puffinus carneipes Gould.

A sizable population of pale-footed shearwaters existed on the Goose Island banks about 18 miles west of the islands. On June 13 between 50 and 60 of these birds were observed at close range. Four birds collected, two males and two females; they were badly moulted, a new greyish plumage contrasting markedly with the chocolate brown of the worn feathers. As the summer progressed the predominance of brown gave way to greyish black. Specimens collected on July 27 were coming into full plumage. By mid-August the population appeared to have dwindled; only scattered birds in full plumage were observed.

PINK-FOOTED SHEARWATER--Puffinus creatopus Coues.

These birds were first observed on the Goose Island banks on July 13 when one individual was seen. On July 27 five were seen in the same area--about 18 miles west of the islands. On August 13 three were observed about 12 miles south of the Goose Islands. On August 14 four were observed in the same area and three days later ten were recorded. Shearwaters of this species seldom came near the boat and were usually in flight. We found them difficult to collect and none was taken.

From these records it appears that the pink-footed shearwater arrived at this latitude later than did the other species present.

FORK-TAILED PETREL--Oceanodroma furcata (Gmelin).

These tiny pelagics were second in numbers only to the sooty shearwater. They foraged in small groups and in singles everywhere on the banks. When the fishing fleet was present the petrels followed, picking up scraps from gutted fish. On several occasions we caught them by hand. This was accomplished by stopping the

boat and scattering small bits of halibut liver about the stern. The petrels dived to recover the bait and upon surfacing were easily seized. Upon release they circled briefly, then returned to continue feeding, apparently unperturbed.

The fork-tailed petrel was most numerous throughout May and well into August on the banks, appearing about the islands in numbers during the night and on foggy days. Despite the nightly occurrence we found no signs of burrows upon the Goose Islands. Upon one occasion (July 14) we anchored for the night some 18 miles west of the islands. In the morning at 3 a.m. just before dawn, several large flocks of fork-tailed petrels passed the boat flying purposefully seaward. This undoubtedly represented a breeding population from some islands at this latitude. We did find a small colony on Fingal Island to the north of the Goose Islands, but this could hardly account for the large numbers observed at sea, samples of which invariably carried brood patches.

After the end of July a noticeable decline in numbers of this species was observed on the banks. The population diminished rapidly until by the middle of August comparatively few birds were seen on the pelagic waters. On the inside channel, however, 25 to 30 birds were observed near Hunter Island on August 17, where previously none had been recorded. The following day on the inside route to Matheson Channel and Kynoch Inlet fork-tailed petrels were very common. Specimens shot here had brood patches but down had filled in over the bare skin. Large concentrations of petrels were observed about the seine boats which were engaged in salmon fishing. It seems obvious that sometime near the beginning of August, the petrels which have finished their breeding activities move into the inside passages. Whether this is due to an abundance of food made available by commercial fishing operations, or whether it is intrinsic behaviour is unknown at present.

BOREAL PETREL--*Oceanodroma leucorhea* (Vieillot).

These birds were seen on only two occasions throughout the summer. One was recorded 12 miles west of the Gosling Rocks on June 26; the other, an adult male with bare brood patches, was collected by night between Goose and Gosling Islands on July 25. This bird was undoubtedly nesting in the area.

Boreal petrels were not observed on the inside waters; they are in fact a bird of the warm "blue water" of the Japanese current (Martin 1949).

BRANDT CORMORANT--Phalacrocorax penicillatus (Brandt).

To date there is no authentic record of this species breeding in British Columbia. It is noteworthy then, that at least six individuals, two in breeding plumage, spent the summer on the Gosling Rocks with a group of pelagic cormorants. However, no record of nesting was secured by us. An adult female taken 10 miles west of the islands on June 26, and an immature female (bursa fabricius 8 mm.) taken June 15 on the Gosling Rocks, were non-breeding individuals.

PELAGIC CORMORANT--Phalacrocorax pelagicus Pallas.

About one hundred of these birds roosted and fed about the Gosling Rocks from the time of our arrival in early May until July 23 when most of them had disappeared.

Early in May most individuals carried the white flank patch which is generally regarded as breeding plumage for this species; a small percentage were in a moulted condition. By the end of May only 8 birds retained the patch, and an increase was noted in the number of badly moulted birds. Either a population movement had occurred or a rapid moult had taken place, but in any event the numbers of birds had remained approximately the same. There was no evidence of nesting anywhere on the Gosling Rocks, but a small colony of 70 birds was located on a reef near White Cliff Island which lies across Queen's Sound. The birds in this colony were still incubating, courting, and carrying nesting material on July 28. It is entirely possible that those seen in breeding plumage on the Goslings were now nesting near White Cliff and that their roost on the Goslings had been taken up by non-breeding individuals, which in turn deserted the area before the end of July.

GREAT BLUE HERON--Ardea herodias Linnaeus.

Herons were not observed upon the Goose Islands until July 6 when two flew in from the east to feed at a creek mouth where our vessel was anchored. Subsequently none was seen until July 21, when three birds frequented the same area, disappearing on July 23. No additional records were secured; herons apparently did not breed on the Goose Island group.

CANADA GOOSE--Branta canadensis (Linnaeus).

Canada geese were nesting on Goose Island while spring migration appeared to be in progress. On May 11 60 geese were observed flying northward at great height; on May 24 50 passed

by the islands and on May 30 an additional 20 passed through. Nesting evidence was first secured on May 24, when a nest containing four eggs was located near a small muskeg pond in the central part of the island. On June 1 the tracks of young birds were observed in the mud of the lagoon and on June 5 four downy young were collected in the same area. From June 1 until June 22 between 40 and 50 Canada geese appeared to be utilizing Goose Island. In the third week of June the birds disappeared, apparently to moult, and were not observed again until July 21 when two were reported in flight off the north end. On August 2, seven geese appeared in the anchorage between Goose and Gosling Islands and on August 3, 47 appeared on the gravel bars at the south end of the main island. By August 12 over 100 of these birds were using the coast littoral at the south end of the group and from August 15 on at least 150 Canada geese frequented the area. It seems probable that these birds represented the nesting adults plus the annual increment.

BRANT--Branta bernicla (Linnaeus).

Brant were observed in obvious migration until the end of May, after which date, from six to ten birds frequented the eel-grass beds about the island for the remainder of the summer. The plumage of these summer residents showed differential wear and was much faded. Towards the end of July three dark-plumaged birds were seen in the anchorage accompanied by four faded individuals. We were unable to ascertain whether the faded birds were new arrivals, but the dark ones most certainly were. Whether they represented forerunners of the fall migration or non-breeding individuals that had remained at this latitude throughout the summer is unknown.

WHITE-FRONTED GOOSE--Anser albifrons (Scopoli).

Between 60 and 80 small geese observed in northward flight west of Goose Island were believed to be of this species. They passed by at an altitude of about 1,000 feet on May 30. On June 25 eight birds observed flying southward were believed to be white fronts, although distance was too great for positive identification.

MALLARD--Anas platyrhynchos Linnaeus.

A small number of mallards bred about the muskeg ponds on the main islands. Mated pairs were flushed on several occasions in

May and the tracks of an adult and six young were seen in June.

No large numbers of spring migrants occurred but Mr. T. Balmer of Ocean Falls reported that mallards were fairly numerous in the fall.

PINTAIL--Anas acuta Linnaeus.

An adult female, emaciated and incapable of flight, was collected on the beach August 12. There was no evidence of mechanical injury, lead poisoning, or gross parasitism in this specimen. It represented the only record of the species for the area.

GREEN-WINGED TEAL--Anas carolinensis Gmelin.

An adult male frequenting the anchorage on July 8 and 9 provided the only record for the islands.

COMMON GOLDEN-EYE--Glaucionetta clangula (Linnaeus).

Six females and four males of this species seen on May 11, and one male on May 20, were the only summer records for the Goose Islands. They had apparently stopped over in migration.

BUFFLE-HEAD--Glaucionetta albeola (Linnaeus).

Sixty buffle-head were observed on May 11, three of which were adult males. On May 20 four females and one male were seen.

These birds were resting in a small tide pool which formed in the lagoon at low tide. The golden-eye recorded above were frequenting the same pool.

OLD SQUAW--Clangula hyemalis Linnaeus.

Four females and one male were recorded on May 11, 14, and 15. Thereafter this species was not seen in the area.

HARLEQUIN DUCK--Histrionicus histrionicus (Linnaeus).

Male and female harlequins were numerous about the rocky shores until May 24. On May 29 a flock of 16 males was observed and later on the same day one male and two females were seen. From May 29 to June 13 harlequin were absent from the island,

reappearing on June 13 when ten adult males in full plumage were observed roosting on a rock in the anchorage. These birds were present along the east side of the island for the remainder of the summer, where they underwent a complete moult. By July 7, about half of the nuptial plumage remained and on July 28 a group of completely flightless birds was seen in the kelp beds near White Cliff Island. Here in attempting to escape they dived and swam in the boiling surf as it ground against the reef. That they were not injured seemed amazing.

A specimen collected was without flight feathers.

WHITE-WINGED SCOTER--Melanitta fusca (Linneaus).

Occasional singles and small flocks passed through Queen's Sound throughout May, June, and into the third week of July. None was recorded after that date.

SURF SCOTER--Melanitta perspicillata (Linneaus).

Several hundred surf scoters were observed passing low over Queen's Sound apparently in migration during the month of May. The movement continued until June 25. On June 8 about 30 birds rested on the coast littoral at the south end of the main island but for the large part the birds recorded were on the move.

AMERICAN MERGANSER--Mergus merganser Linneaus.

These birds were observed twice in May. On the 11th a lone female appeared in the lagoon, and on the 29th a full-plumaged pair was seen on the coast littoral. From that date until June 20 none was recorded, following which several small flocks probably representing family groups were observed until July 18. There were no full-plumaged males observed after June 20.

RED-BREASTED MERGANSER--Mergus serrator Linnaeus.

From May 11 to May 24 several small groups of full-plumaged birds frequented the coast littoral about the Goose Islands. After the latter date they were not recorded again.

GOSHAWK--Accipiter gentilis (Linnaeus).

A large accipiter observed working over the muskegs on June 20, was believed to be of this species.

SHARP-SHINNED HAWK--Accipiter striatus Vieillot.

A pair of these birds frequented the Goose Islands in June. They were observed on three occasions only, June 4, 7, and 28. None was collected.

BALD EAGLE--Haliaeetus leucocephalus (Linnaeus).

Bald eagles were extremely numerous in the Goose Island area and at least four pairs nested on the group. A nest examined on June 25 contained one large bird in juvenal plumage which was almost ready to leave the nest. This and other nests were located from 50 to 60 feet above the ground in tall spruce trees.

The north end of Goose Island and the Broken Group Islands a short distance to the north appeared to be a favourite roosting area for these birds. As many as 60 individuals were observed on several occasions, 90 per cent of them fully adult. On several occasions tight flocks of from 50 to 60 eagles were observed feeding over the sea where sand lance or herring had surfaced.

The concentration of eagles appeared to occur in May and June, the numbers decreasing in the late part of the summer.

DUCK HAWK--Falco peregrinus Tunstall.

A single adult bird was observed on four occasions in May and early June, foraging about the Goose Islands, but no evidence of nesting was found.

In mid-July and August, juveniles passed the islands regularly, often stopping to work the sandpipers in the lagoon. Though we observed several stoops and pursuits we never once saw a kill; observations which contrasted sharply with those of adult birds on the Queen Charlottes.

BLUE GROUSE--Dendragapus sp.

We found no evidence whatsoever of gallinaceous birds upon these islands.

SANDHILL CRANE--Grus canadensis (Linnaeus).

On August 15 the characteristic call of this species was heard at dusk from the lagoon. Judging by the volume of noise, a sizable

flock passed southward down the west coast of the group in low flight. They were not seen because of timber standing between the lagoon and the sea.

BLACK OYSTER-CATCHER--Haematopus bachmanii Anderson.

Approximately one hundred black oyster-catchers frequented the islands throughout the summer. Three or four groups of from six to twelve very noisy birds remained as flocks and apparently did not breed. The remainder were scattered in pairs and threes along the shore line where they frequented rocky headlands and islets not covered at high tide. On these areas 17 nests were located in late May and early June, but none contained eggs. On June 25 a nest was found containing one damaged egg which showed evidence of crow predation. Judging from the number of crows foraging along the shore line it is not surprising that no eggs were found. Plumage of the non-breeding flocks showed evidence of heavy differential wear, fading, and moult by June 21, while the breeding birds appeared much darker with plumage only slightly worn.

SEMIPALMATED PLOVER--Charadrius hiaticula Linnaeus.

These plovers were on the mud flats and sand beaches in large numbers from May 11 until May 24.

On July 9 they reappeared in small flocks moving southward. The size of the flocks gradually increased until by mid-August 75 to 100 of these birds was not an uncommon sight on the mud flats of the lagoon.

GOLDEN PLOVER--Pluvialis dominica (Muller).

Five golden plover rested on the mud flats of the lagoon on June 6. No others were seen.

BLACK-BELLIED PLOVER--Squatarola squatarola (Linnaeus).

Three small flocks of seven, five, and two stopped over on May 11, May 12, and June 7, respectively. The flock of five frequented the gravel beaches of the anchorage until May 17. None was seen in fall migration.

TURNSTONE--Arenaria interpres (Linnaeus).

On May 12 eight turnstones were seen on a sandy sea beach with a flock of dowitchers and black-bellied plover. On May 20 a single turnstone which arrived with three knots was collected. These birds were in full nuptial plumage and apparently were late spring migrants. None was seen in full migration.

BLACK TURNSTONE--Arenaria melanocephala (Vigors).

No black turnstones were seen in the spring; two flocks recorded on July 21 and 23 were obviously fall migrants.

SPOTTED SANDPIPER--Actitis macularia (Linnaeus).

A small nesting population occurred on the islands from May through August. Young of the year were observed foraging with a parent bird on August 15; the adult when collected proved to be a male.

Spotted sandpipers frequented the mouths of fresh water rills emptying on the lagoon, and sandy beaches at various protected points along the outer shoreline.

GREATER YELLOW-LEGS--Totanus melanoleucus (Gmelin).

The first yellow-legs observed on the Goose Islands appeared on June 28 when a single bird passed over the lagoon at an altitude of approximately 1000 feet and disappeared to the south. From that date small flocks of three to six birds were observed at various intervals until August 12. As no specimens were collected on Goose Island, it is possible that some of these migrating birds were lesser yellow-legs.

LESSER YELLOW-LEGS--Totanus flavipes (Gmelin).

The only positive record of this species in the area is based on a specimen taken at Spider Island, across Queen's Sound from the group under study.

KNOT--Calidris canutus (Linnaeus).

On May 20 three knots and a turnstone flew past our anchored vessel and landed on a gravel beach at the north end of Gosling Island.

The one bird collected was in full breeding plumage. This species was not seen again in the area.

BAIRD SANDPIPER--Erolia bairdii (Coues).

Three birds of this species were recorded in spring migration. A female feeding with "peeps" was taken on a sandy sea beach on May 11; a lone individual feeding with three western sandpipers in the same area on May 22 was not collected; a single, feeding with a flock of fifty dunlin, was collected on May 24. This species was not seen again on the islands.

LEAST SANDPIPER--Erolia minutilla (Vieillot).

From May 11 until July 10 members of this species were observed regularly in varying numbers on the mud flats and sandy sea beaches where they usually fed in company with western sandpipers which were in northward migration with them. After an interval of eight days least sandpipers reappeared in fall migration when ten individuals arrived at the lagoon. Two days later, on July 20 large numbers arrived and remained for a two-day period before disappearing to the southward. From this date on the migration intensified and numbers of least and western sandpipers were present continuously until August 17 at least, when the last observation was made.

DUNLIN--Erolia alpina (Linnaeus).

Approximately three hundred individuals of this species passed through the Goose Islands in spring migration. They rested upon the lagoon flats at low tide, appearing in various-sized flocks from May 11 until June 7. Eight individuals arrived on July 9; whether they were late northward stragglers or early southward migrants was undetermined. In any event none was observed in late July and August when other sandpipers were moving south in numbers, indicating perhaps that this species migrates later in the fall, or uses another route in south-bound migration.

DOWITCHER--Limnodromus griseus (Gmelin).

Ten specimens were collected on May 11 and May 12 on a sandspit near the anchorage. Thirteen birds were recorded in spring migration. On July 10 a single dowitcher was flushed from the meadows about the lagoon and on July 23 one was collected in the same area, while tracks in the mud indicated more had been frequenting the spot.

Birds collected were approaching or were in full breeding plumage. None was seen in August.

WESTERN SANDPIPER--Ereunetes mauri Cabanis.

These birds migrated and fed with the least sandpipers and appeared in equal numbers, as far as we were able to determine. Dates and remarks pertaining to the least sandpiper may be applied here.

SANDERLING--Crocethia alba (Pallas).

Sanderling were recorded in fall migration on three occasions; August 3, one individual. August 12, three individuals, and August 15, two individuals. None was seen in spring migration.

These birds were all observed on the tidal mud flats of the lagoon in company with western and least sandpipers.

RED PHALAROPE--Phalaropus fulicarius (Linnaeus).

Two red phalaropes were observed at close range in a tide line west of the Goose Islands on July 28. On this date fishermen on the banks reported large flocks of "Coho birds" which may have been of this species. The large part of the migration, however, passes along the warm "blue waters" of the Japanese current far to the westward according to Patrick Martin.

NORTHERN PHALAROPE--Lobipes lobatus (Linnaeus).

A small northward movement was observed passing the Goose Island from May 22 to May 27. Subsequently no phalaropes were seen until June 26 when the southward movement began; by July 13 they were extremely numerous throughout Queen's Sound feeding in the tide lines. Small flocks continued to pass the islands until the last observation on August 16.

POMARINE JAEGAR--Stercorarius pomarinus (Temminck).

No pomarine jaegars were observed until June 13 when a lone individual in very dark plumage was seen about 18 miles west of Goose Island. None was subsequently recorded until July 13 when three birds were seen. Two of these when collected proved to be females, both showing signs of brood patches recently "downed over."

In late July and August the species was observed on every trip to pelagic waters. Five birds collected were females none of which showed evidence of the brood patch.

The birds were feeding upon the entrails of coho which had been discarded by a large fishing fleet operating on the banks at the time.

PARASITIC JAEGAR--Stercorarius parasiticus (Linnaeus).

On June 10 two of these birds were observed about 15 miles west of the island performing aerobatics together. None was seen after that date until August 14, when a lone female was collected twelve miles north of the group.

The proventriculus of this specimen contained sand lance.

SKUA--Catharacta skua (Brunnich).

Two skuas were observed about 18 miles west of Goose Island, one on June 13, and one on June 27. The latter bird when collected proved to be a dark-coloured female: it had been feeding upon entrails of trolled coho.

On August 17 a large pale female was collected 12 miles south of the island; this bird had been feeding upon sand lance.

No others were observed during the summer.

GLAUCOUS-WINGED GULL--Laurus glaucescens Naumann.

Approximately three hundred glaucous-winged gulls nested on the Goose Islands, the great majority centred on the Gosling Rocks. The birds were on territory May 11. Nests in various stages of construction were examined on May 27 but no eggs were seen until June 8 when two nests containing a total of three eggs were examined. These eggs subsequently disappeared as did practically all of those laid at this time. Crows and native fishermen raided the colony regularly so that the first hatch did not come off until July 11. On August 3 the colony was revisited: eggs, downy young, and individuals wearing full juvenal plumage were present in numbers.

A colony of approximately 30 pairs was observed on Fingal Island August 4. Downy young and eggs occupied most nests.

Immature birds of previous nesting seasons frequented the colonies along with the adults throughout most of the month of May. Thereafter they apparently were not tolerated: they appeared sporadically on pelagic waters where adult birds were absent. Late in August a few adults began to show on the banks. These probably represented breeding birds which had nested earlier than the majority.

HERRING GULL--Larus argentatus Pontoppidan.

Herring gulls were scarce in the area. Two adult birds were observed in the coast littoral on May 17, three juveniles in complete grey phase on June 9, and on June 15 two observed near the Gosling Rocks were recorded as yearling and two year old birds. No others were seen throughout the summer.

SHORT-BILLED GULL--Larus canus (Linnaeus).

Though plentiful about the islands to the east this species was practically absent on the Goose Islands. One was seen May 25.

This species was found nesting on Princess Royal Island where specimens of downy young were collected at Broomfield Lake on July 4.

BONAPARTE GULL--Larus philadelphia (Ord).

A lone individual observed in the anchorage on May 13 was the only positive record for the island proper. In August, however, some of the large flocks of small gulls observed at a distance were probably of this species, although Sabine gulls were observed at that time of year, and the possibility of kittiwakes occurring was strong though we recorded none.

SABINE GULL--Xema sabini (Sabine).

Single sabine gulls were observed on three occasions, June 9, June 26, and July 28. The first two were on pelagic waters: the other, collected on the coast littoral was an immature male.

Several large flocks of small gulls observed at a distance over pelagic waters in August may have been of this species.

COMMON MURRE--Uria aalge (Pontoppidan).

These birds were present in numbers throughout the summer. They were observed in groups of from two to eight individuals except on July 28 when large flocks of from 25 to 50 birds were seen. Murres frequented the coast littoral of the Goose Islands and extended into the pelagic waters an unknown distance, but they were still numerous 22 miles west of the islands, the point of our most westward penetration.

A specimen taken on May 27, and one taken on July 8 were both in a state of moult and neither showed any sign of breeding. There was no evidence of nesting in the Goose Island area.

PIGEON GUILLEMOT--Cepphus columba Pallas.

From May 11 until May 17, pigeon guillemots were scattered generally throughout the coast littoral of the coast islands with no apparent suggestion of concentration. In the third week of May, however, a definite concentration took place about the rocky islands where slab rock (Fig. 22) and beach debris occurred. Ninety-eight birds were counted about Gosling Island where previously only scattered individuals had been observed. Six concentrations were located about the islands and a total numbering in the vicinity of a thousand breeding birds was estimated.

The preferred nesting sites appeared to be in slab rock which occurred on the shore in some areas. Coarse beach debris comprised of large immovable logs was also utilized and on the north end of the islands ten freshly prepared burrows were examined on May 29. These had been excavated between the native rock and the overburden of soil where clean cut "faces" abutted on the sea. (Fig. 21).

By May 25, courting behaviour and copulation were observed; first eggs were collected on June 7; adults were first observed carrying feed to the nesting colonies on July 6; and the first young were observed on the water August 6. Late courting behaviour and copulation (unenthusiastic) was observed throughout the month of July.

On July 8 scattered adult individuals observed eighteen miles west of the Goose Island provided the only record of this species on pelagic waters.

MARBLED MURRELET--Brachyramphus marmoratus (Gmelin).

In May marbled murrelets were observed in the coast littoral on only four occasions. On three of these occasions a single pair was seen. One of these birds, collected on May 20, was in a non-breeding condition. On the fourth occasion, two pairs observed together were collected on May 31. One pair (male and female) was incubating, both male and female having a bare brood patch; the other apparently was a non-breeding pair. In June there was a definite increase in numbers about the islands: 21 pairs were counted off the south shore of Goose Island.

On June 25, the first juvenile was seen on the water; the bird was accompanied by no less than eight adults. Throughout the remainder of June and July, single young were seen with two adults on many occasions, indicating that the hatch had come off during that time.

On July 2 at Higgins Pass a large group of adult murrelets was observed clustered in flocks containing up to 25 individuals, the whole group totalling in the neighbourhood of 150 pairs. Five young were observed in this group. Such concentrations seem to precede the general appearance of young marbled murrelets upon the sea.

On several occasions throughout the summer adults of this species were seen in small numbers on pelagic waters.

ANCIENT MURRELET--Synthliboramphus antiquus (Gmelin).

Adult ancient murrelets were observed in flocks of 15 to 25 individuals in June: they were foraging in pelagic waters.

On June 13 eight family groups (two adults, two young) were seen about 20 miles west of the Goose Islands, the young in each case appeared to be newly hatched birds. On June 25 the birds began to appear in the coast littoral but only when the young had almost attained the size of the parents. On no occasion were small downies encountered in the coast littoral. By June 30 adults and young in full juvenal plumage were common in the channels about the Goose Islands, where they remained throughout the summer.

We secured no evidence that these birds nested on the group.

CASSIN AUKLET--Ptychoramphus aleuticus (Pallas).

Cassin auklets were recorded throughout the summer only as scattered individuals and pairs. They occurred only on pelagic waters.

Fig. 21. Nesting burrows of Pigeon Guillemot at junction of rock face and top soil.

Fig. 22. Pigeon Guillemot nesting sites in broken rocky shore on Goose Island.

One bird observed on July 8 about 12 miles southwest of Goose Island was recorded as "young of the year" on the basis of what appeared to be remnants of natal down adhering to the head and back. We failed to collect the specimen.

As far as we were able to determine this species did not nest in the vicinity.

RHINOCEROUS AUKLET--Cerorhinca monocerata (Pallas).

Full-plumaged adults of this species were extremely numerous in coast littoral and pelagic waters throughout the summer.

First appearance of young was recorded on August 11. Thereafter they were most numerous throughout the coast littoral. It seemed likely that a large breeding colony occurred in the area, or that perhaps, the adults observed nested in scattered pairs over a large range. At any rate, we found no such colony or burrow on the Goose Islands.

TUFTED PUFFIN--Lunda cirrhata (Pallas).

Thirteen puffins were recorded from May 13 through August 17. These were seen as single birds and pairs in flight over pelagic waters. None was seen within 12 miles of the coast line.

SCREECH OWL--Otus asio (Linnaeus).

At least two pairs of screech owls nested in the coniferous forest on the Goose Islands. Juveniles which had left the nest were collected on June 30.

These birds were recorded foraging the beaches at dusk, where they obviously fed upon fish. (Guiguet 1949).

RUFOUS HUMMINGBIRD--Selasphorus rufus (Gmelin).

These birds nested in numbers upon the Goose Islands, where they occurred throughout the summer months. They frequented the forest edge where salmonberry and honeysuckle occurred.

The last record of adult male was made on June 12; thereafter only birds in female and immature plumage were observed.

BELTED KINGFISHER-- Megaceryle alcyon (Linnaeus).

At least three and possibly four pairs of kingfishers frequented the east coast of Goose Island in May, June, and early July. Courting behaviour and copulation was observed on June 11 at the anchorage but no nests or young were recorded anywhere on the islands.

RED-SHAFTED FLICKER--Colaptes cafer (Gmelin).

Flickers were present in numbers on the Goose Islands throughout the summer.

A nest containing four young in juvenal plumage was examined on July 10. The young were about to leave the nest which was situated in a dead spruce at the edge of the lagoon.

RED BREASTED SAPSUCKER--Sphyrapicus ruber (Gmelin).

The trunks of many tees bore ample evidence that this species had occurred in numbers upon the Goose Islands, but not a single individual was recorded from May through August. It seems evident that the island is utilized by the species at another season of the year. There has been no marked decline in the species along the coast as far as we are able to ascertain.

HAIRY WOODPECKER--Dryobates villosus (Linnaeus).

These birds occurred in widely scattered pairs throughout the coniferous forest. A specimen collected on June 5 which was or had recently been incubating (brood patch) and an immature male collected July 12, were regarded as definite evidence of breeding. No nest was found.

WESTERN FLYCATCHER--Empidonas difficilis Baird.

This was the only flycatcher recorded in the area. They frequented the edge of the coniferous forest were deciduous shrubbery and trees occurred: they were present throughout the summer. Singing males were recorded during June and early July and a female taken on June 21 was incubating.

VIOLET-GREEN SWALLOW--Tachycineta Thalassina (Swainson).

One individual was observed feeding over the lagoon at low tide on June 6. No others were recorded.

BANK SWALLOW--Riparia riparia (Linnaeus).

On July 21 a single bank swallow was collected over the lagoon at low tide. This was the only specimen seen.

BARN SWALLOW--Hirundo rustica Linnaeus.

Two barn swallows were observed feeding with the violet-green recorded on June 6. No others were seen.

STELLER JAY--Cyanocitta stelleri (Gmelin).

That this species was not recorded on the Goose Islands is worthy of note.

RAVEN--Corvus corax Linnaeus.

Several pairs of ravens nested on the Goose Islands. Young in flight were observed on June 2 and on June 10 adults were observed feeding young on the rocks.

Ravens were observed foraging in the slab rock where guillemots nested; although no actual predation was observed, the actions of the guillemots indicated that the raven was a very real menace.

The species was present throughout the summer months.

NORTHWESTERN CROW--Corvus caurinus Baird.

Approximately eighty crows frequented breeding sites on the Gosling Rocks, and at the northern and southern extremities of Goose Island. Twelve nests were found in low crab-tree thickets and one was located on the ground overhanging salal at a cliff edge.

Fledgling young were collected from a nest on June 15. The crows foraged regularly over the breeding colonies of gull and oyster-catcher throughout the month of June and probably delayed the successful nesting of these species to some extent.

CHESTNUT-BACKED CHICKADEE--Parus rufescens Townsend.

Chickadees were present throughout the summer. Adults were observed foraging about the forest edge during early June, and by the end of that month the young were foraging with the parent birds.

First young were observed on June 25 when two juvenile females were collected. Subsequently family groups were observed regularly during the remainder of the summer.

RED-BREASTED NUTHATCH--Sitta canadensis Linnaeus.

These birds were heard and seen only occasionally throughout May, June, and early July. In late July, and for the duration of August, however, there appeared to be a marked increase in either the number of birds present, or in the calling activity. At any rate the forest was noisy with their calls throughout that period.

A juvenile female collected on July 19 was the only breeding record secured on the Goose Island group.

BROWN CREEPER--Certhia familiaris Linnaeus.

The call of this species heard twice, on May 11 and May 12, constitutes our only record for the Goose Islands.

WINTER WREN--Troglodytes troglodytes Linnaeus.

Every coniferous swale on the island appeared to be frequented by these diminutive songsters. Throughout May and June only adult birds were noted for the large part. Several specimens were collected.

On June 15 an adult was seen busily feeding five young birds which were out of the nest, and from that date throughout the remainder of the month such family groups were seen on several occasions.

A nest containing five fresh eggs, located in the roots of a fallen spruce on July 12 probably represented a second nesting.

AMERICAN ROBIN--Turdus migratorius Linnaeus.

Scattered pairs were observed at various intervals along the forest edge throughout the summer. A breeding female (brood patch) was collected on June 3, but we recorded no young and no nests were located.

VARIED THRUSH--Ixoreus naevius (Gmelin).

Varied thrush were present in the coniferous forest throughout the summer. A pair collected on June 7 were obviously concerned over the presence of young in the area, but none was seen; while no nests or immature birds were collected it is almost certain that the species nested on the Goose Island group.

HERMIT THRUSH--Hylocichla guttata (Pallas).

These secretive birds frequented the inner peripheries of the coniferous forest where muskeg occurred. The singing males were heard throughout May, June, and mid-July. First young were seen out of the nest on June 21, and others were subsequently seen foraging with the parent birds. No nest was found.

SWAINSON THRUSH--Hylocichla ustulata (Nuttall).

This thrush showed a definite preference for the coniferous forest edge at the sea, rather than on the inner periphery as did the hermit thrush. Throughout May they were comparatively scarce, but in June a marked increase was noted in singing males and by mid-June, at least 20 pairs seemed to have established territory about the south end of the group. No nests or downy young were found, and foraging young had not appeared by mid-July, when for some unknown reason no further records of this species were kept.

GOLDEN-CROWNED KINGLET--Regulus satrapa Lichenstein.

These residents of the upper canopy were heard and seen only in the coniferous forest. They were present in small numbers throughout the summer; family groups first appeared on June 4, and were present until our departure in mid-August. No nests, eggs, or fledgling young were seen.

RUBY-CROWNED KINGLET--Regulus calendula (Linnaeus).

The song of this species was heard continuously throughout May and June. The males appeared to prefer lodgpole pines about 20 or 30 feet high from which to sing, and the birds were most frequently seen where deciduous shrubbery bordered on muskeg and coniferous forest.

A nesting pair collected on June 21 was beginning to moult and obviously had young in the immediate vicinity although none was secured.

VIREO--*Vireo* sp.

We recorded no vireos whatsoever upon the Goose Islands.

ORANGE-CROWNED WARBLER--*Vermivora celata* (Say).

The western race of this species was the only warbler we saw upon the Goose Islands. They were numerous and frequented the peripheries of the coniferous forest throughout the group. Mr. Martin estimated that there was one singing male to every 200 yards of "edge" around Gosling Island.

The birds were present throughout our stay upon the islands. Males were in full song until June 21: first young out of the nest were observed on June 29 foraging with a parent bird in the salmonberry canes.

On August 16, the last date of record, this species was still the most numerous passerine on the Goose Islands.

COWBIRD--*Molothrus ater* (Boddaert).

On August 11 Mr. Martin and myself observed a cowbird arrive upon a high beach with a flock of semipalmated plover. Upon our approach the plovers took wing accompanied by the cowbird; the flock circled back out over the sea for several hundred yards, wheeling in to land farther up the beach. This procedure was repeated four times before we succeeded in collecting the cowbird, which proved to be an immature female.

We recorded no other cowbirds in the Goose Island area.

WESTERN TANAGER--*Piranga ludoviciana* (Wilson).

A pair in beautiful plumage was observed on August 16, perched on a tall spruce near the lagoon.

No others were recorded on the islands.

RED CROSSBILL-Loxia curvirostra Linnaeus.

Red crossbills were numerous about the island until June 28. They were usually observed in small flocks of from eight to ten birds, but on two occasions flocks in excess of 50 were seen. Most of the observations were of birds on the wing or foraging in the upper canopy of the coniferous forest.

From June 28 until July 20 this species seemed to have left the islands; we recorded none in that period. After July 20 they reappeared in numbers.

Three specimens taken from flocks on June 5 and June 11 were adult non-breeding birds, (testes and ovary minute).

SAVANNAH SPARROW--Passerculus sandwichensis (Gmelin).

Small flocks of savannah sparrows were observed in migration from May 11 until May 20, after which date none was seen. They frequented the boulder beach and beach debris habitats for the large part but on a few occasions individuals were flushed from grass in the meadow habitat.

OREGON JUNCOS--Junco oreganus (Townsend).

Juncos frequented the edge of the muskeg at the coniferous forest and were often seen foraging in open muskeg. Breeding pairs were observed throughout May and June; first young out of the nest were collected on June 4. On June 21, five adult birds were collected, all in a state of moult; by inspection of gonads two were breeding males, one was a breeding female, and two were non-breeding females.

Juncos were much less numerous during August than they had been throughout the summer, which indicated perhaps that a migratory movement from the islands had taken place late in July.

GOLDEN-CROWNED SPARROW--Zonotrichia coronata (Pallas).

A flock of 70 individuals was seen foraging through the beach debris at the coniferous forest edge on May 12 to May 15. A single bird was seen on May 11 and two on May 17 in coniferous forest. Subsequently none was seen.

FOX SPARROW--Passerella iliaca (Merrem).

The song of this species was heard on six occasions in May and early June but none was seen.

SONG SPARROW--Melospiza melodia (Wilson).

These birds nested in the forest edge at the sea, foraging for the large part among the beach debris. Singing males were on territory by May 15: first young from the nest were observed and collected on June 12: adults were seen gathering food for young as late as July 15.

By August 15 most of the adult song sparrows were in an advanced state of moult. At this time the population appeared to have moved from the forest edge and beach debris to the heavy grass cover on the meadows.

SUMMARY AND CONCLUSIONS

1. The Goose Island group represents a well isolated ecological unit typical of many outer fringe islands along the British Columbia coast.

2. Eleven major vertebrate habitats occur upon the islands--beach debris, coniferous forest, muskeg, meadow, rocky seashore, boulder beach, tidal and flat, sandy sea beach, coast littoral, pelagic, and fresh water habitat. The latter is not discussed in the foregoing paper.

3. The terrestrial mammalian fauna is represented by three species of small mammals--Peromyscus maniculatus, Microtus longicaudus, and Sorex obscurus. Two species of bats also occur--Lasionycteris noctivagans and Myotis yumanensis. A species of Castor once inhabitated the islands.

4. The small population of bats occurring were confined chiefly to the environs of the coniferous forest. The small number representing both species is attributed to the effect of wind.

5. Peromyscus maniculatus was the most evenly distributed and most abundant species of terrestrial mammal present. Sixty-three per

cent of the total catch was comprised of this species. Distribution by habitat appeared as follows: beach debris, 46.79 per cent; coniferous forest, 25.54 per cent; muskeg, 17.38 per cent; and meadow, 10.29 per cent. The availability and variety of food, nesting sites, and the relative dryness of the habitats appeared to be the major factors accounting for this distribution.

6. Microtus longicaudus was restricted to areas in which grasses occurred. This species was the least abundant of the three terrestrial forms present, representing approximately 14 per cent of the total catch. The catch was distributed as follows: beach debris, 13.33 per cent; coniferous forest, 06.67 per cent; muskeg, 10 per cent; and meadow, 70 per cent. Density of grass cover and the nature of ground bases in the habitat types are considered as major factors contributing to this distribution.

7. Sorex obscurus represented 23 per cent of the total take of terrestrial forms. Of this species 27.78 per cent were taken in beach debris, 11.11 per cent in coniferous forest, 11.11 per cent in muskeg, and 50 per cent in the meadow. The factors leading to this distribution are obscure. In gross analysis the only apparent factor is density of the grass cover.

8. Sex ratios based on snap trappings were indicated as 1:1 in Peromyscus maniculatus and Microtus longicaudus. A 3:1 ratio, male predominant, was observed in Sorex obscurus. This ratio seems to be correlated with the appearance of running young and is considered due to mortality in females and/or other undetermined changes associated with breeding.

9. Peripheral habitat bordering the sea, represented by beach debris and meadow, is preferred summer range for the terrestrial forms. Winter signs correlated with trapping data indicates that a reversal of optimal conditions with change of season results in population movements from peripheral to interior habitats, the latter represented by coniferous forest and muskeg. This seasonal movement is preceded by the annual increment of young from peripheral habitats due to population pressure. In the latter case due to lack of durable sign, the activities of Sorex obscurus are assumed.

10. Limpets and small crabs form regular items in the summer diet of coastal Peromyscus.

11. Predation as a factor influencing small mammals was non-existent in the summer months of 1948 on Goose Islands.

12. The indigenous avian population was concentrated around the periphery of the Goose Islands --at the edge of the coniferous forest and the sea. In numbers of species occurring this exposed habitat was far more productive in summering birds than were all of the other habitats combined. The inner coniferous edge around and in the muskegs, despite a sheltered nature produced comparatively few birds, chiefly hermit thrush, junco, and ruby-crowned kinglet. The coniferous forest proper, notorious elsewhere in non-productivity of avian life, conformed to type on the Goose Islands. Apart from occasional large flocks of red crossbills in the canopy, scattered hairy woodpeckers on the trunks, varied thrush and winter wrens on the forest floor, the deep woods were practically birdless, as most individuals of these species preferred the outer edge.

    This concentration of life on the outer periphery of British Columbia's coastal islands has been recorded previously by many workers. Apparently the superabundance and variety of food is the controlling factor.

13. Spring migration was still in progress upon our arrival on the Goose Islands on May 13. This northward movement declined rapidly in early June and finally petered out completely by July 10 when a few western and least sandpipers were recorded. On July 21 a large number of southbound sandpipers appeared on the flats and from that date the fall migration appeared to be intensifying steadily. This early movement was made up largely of shore birds.

14. The pelagic community appeared sedentary for the large part, although halibut fishing operations on the Goose Island banks in May appeared to attract and concentrate black-footed albatross on the fishing area. Throughout June and July, however, after halibut fishing was terminated, the population appeared to be dispersed and only single birds were recorded. A movement of fork-tailed petrel was apparent in July when a large part of the population moved to the inside waters: this movement continued until late August when very few petrels remained on pelagic waters. A southward movement of pomarine jaegars appeared on pelagic waters west of the Goose Islands in mid-August and the species was present upon the banks until our departure on August 16.

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CHECK LIST OF GOOSE ISLAND BIRDS

Gavia immer (Brunnich).

Gavia arctica pacifica (Lawrence).

Diomedea nigripes (Audubon).

Puffinus tenuirostris (Temminck).

Puffinus griseus (Gmelin).

Puffinus opisthomelas Coues.

Puffinus carneipes Gould.

Puffinus creatopus Coues.

Oceanodroma furcata plumbea (Peale).

Oceanodroma leucorhoa (Vieillot).

Phalacrocorax penicillatus (Brandt).

Phalacrocorax pelagicus pelagicus Pallas.

Ardea herodias fannini Chapman.

Branta canadensis occidentalis (Baird).

Branta bernicla nigricans (Lawrence).

Anser albifrons albifrons (Scopoli).

Anas platyrhynchos platyrhynchos Linnaeus.

Anas acuta Linnaeus.

Anas carolinensis Gmelin.

Glaucionette clangula (Linnaeus).

Glaucionetta albeola (Linnaeus).

Clangula hyemalis (Linnaeus).

Histrionicus histrionicus (Linnaeus).

Melanitta fusca (Linnaeus).

Melanitta perspicillata (Linnaeus).

Mergus merganser americanus Cassin.

Mergus serrator (Linnaeus).

Accipiter gentilis atricapillus (Wilson).

Accipiter striatus perobscurus Snyder.

Haliaeetus leucocephalus washingtoniensis (Audubon).

Falco peregrinus pealei Ridgway.

Grus canadensis (Linnaeus).

Haematopus bachmanii Anderson.

Charadrius hiaticula semipalmatus Bonaparte.

Pluvialis dominica (Muller).

Squatarola squatarola (Linnaeus).

Arenaria interpres morianella (Linnaeus).

Arenaria melanocephala (Vigors).

Actitis macularia (Linnaeus).

Totanus melanoleucus (Gmelin).

Totanus flavipes (Gmelin).

Calidris canutus (Linnaeus).

Erolia bairdii (Coues).

Erolia minutilla (Vieillot).

Limnodromus griseus griseus (Gmelin).

Ereunetes mauri Cabanis.

Crocethia alba (Pallas).

Phalaropus fulicarius (Linnaeus).

Lobipes lobatus (Linnaeus).

Stercorarius pomarinus (Temminck).

Catharacta skua antarctica Lesson.

Larus glaucescens Naumann.

Larus argentatus smithsonianus (Coues).

Larus canus brachyrhynchos Richardson.

Larus philadelphia (Ord).

Xema sabini woznesenskii Portenko.

Uria aalge inornata Salomonsen.

Cepphus columba columba Pallas.

Brachyramphus marmoratus (Gmelin).

Synthliboramphus antiquus (Gmelin).

Ptychoramphus aleuticus aleuticus (Pallas).

Otus asio kennicotti (Elliot).

Selaphorus rufus (Gmelin).

Megaceryle alcyon (Linnaeus).

Colaptes cafer cafer (Gmelin).

Sphyrapicus ruber ruber (Gmelin).

Dryobates villosus sitkensis Swarth.

Empidonax difficilis difficilis Baird.

Tachycineta thalassina lepida Mearns.

Riparia riparia (Linnaeus).

Hirundo rustica erythrogaster Boddaert.

Corvus corax principalis Ridgway.

Parus rufescens rufescens Townsend.

Sitta canadensis Linnaeus.

Certhia familiaris Linnaeus.

Troglodytes troglodytes pacificus Baird.

Turdus migratorius caurinus (Grinnell).

Ixoreus naevius naevius (Gmelin).

Hylocichla guttata nanus (Audubon).

Hylocichla ustulata ustulata (Nuttall).

Regulus satrapa olivaceous Baird.

Regulus calendula grinnelli Palmer.

Vermivora celata lutescens (Ridgway).

Molothrus ater artemisiae Grinnell.

Piranga ludoviciana (Wilson).

Loxia curvirostra sitkensis Grinnell.

Passerculus sandwichensis (Gmelin).

Junco oreganus oreganus (Townsend).

Zonotrichia coronata (Pallas).

Passerella iliaca (Merrem).

Melospiza melodia rufina Bonaparte.

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